Effective Date: November 11, 2020
Expiration Date: Five years from date of last change
Responsible Organization: GOES-R Program/Code 410

410-R-RIMP-0313
Version 2.0

Geostationary Operational Environmental Satellite (GOES) – R Series

Geostationary Lightning Mapper (GLM) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

November 2020

U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Satellite and Information Service (NESDIS)
National Aeronautics and Space Administration (NASA)

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Geostationary Lightning Mapper (GLM) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)

Revision Prepared by:

Approved via email – attached to the CCR 09/01/2020
Katherine Pitts Date
GOES-R Product Readiness and Operations Cal/Val Support

Submitted by:

Electronically signed by: 09/10/2020
Matthew Seybold Date
GOES-R Product Readiness and Operations Manager

Concurred by:

Approved via email – attached to the CCR 09/22/2020
William Koshak Date
Senior Scientist, GLM

Approved via email – attached to the CCR 09/28/2020
Jaime Daniels Date
GOES-R Algorithm Working Group Lead

Electronically signed by: 09/10/2020
Melissa Dahya Date
GOES-R Flight PLT Director

Approved by:

Electronically signed by M. Todirita for: 10/14/2020
Candace Carlisle Date
GOES-R Flight Project Manager

Electronically signed by: 10/28/2020
James Valenti Date
GOES-R Ground Segment Project Manager

Electronically signed by: 11/11/2020
Pamela Sullivan Date
GOES-R Series System Program Director

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Document Change Record

	DOCUMENT TITLE: Geostationary Lightning Mapper (GLM) Beta, Provisional and Full Validation Readiness, Implementation and Management Plan (RIMP)			
VERSION	**DATE**	**CCR #**	**PAGES AFFECTED**	**DESCRIPTION**
1.0	06/02/2016	03119	All	Initial
1.1	12/23/2016	03263	1, 2, 4, 6, 15-22	Updated Preface text & Fig 2; added last paragraph to Sec 1; updated Fig 3; added "Reference MRD" to Appendix A; updated interferometer details; added border to table 1
1.2	07/19/2017	03321	3, 6, 12, 15, 16, 27, 29, 32, 33, 34	Updated Sec 5.2, A.1, to clarify Beta criteria; Updated Sec A.1.2 because NALMA now augmented by interferometers in B.18; Updated Sec B.18 to reflect new interferometer in Huntsville; Fig 3 updated; Sec 1, C.1 updated with additional testing planned by Lockheed Martin.
2.0	11/11/2020	03617	Numerous	Revision 2.0 – refresh for T & U

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Table of Contents

Preface 1
1. GLM Validation Overview 5
2. Schedule of Events 9
3. Roles and Responsibilities 12
4. Tools 14
5. Pre-launch 16
6. References 17
A. Appendix A: Post-Launch Product Tests 18
B. Appendix B: GOES-R Series and Validation Reference Data 29
C. Appendix C: PLT Details 37
D. Appendix D: Tools 41
E. Appendix E: Acronyms 46

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

List of Figures

Figure 1. GOES-R product maturity levels. 3
Figure 2. Delineation of RIMP execution accountability between GOES-R and CWG/AWG. 4
Figure 3. The post-launch validation schedule. 9

List of Tables

Table 1. Beta Validation PLT test IDs, short titles, and execution status per satellite.. 6
Table 2. PLPT series ID, short title, and execution status for each satellite 7
Table 3. Post-launch science product validation schedule for GLM 9
Table 4. GLM roles and responsibilities 12
Table 5. Listing of all data sources potentially employed for GLM PLPT. 29

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Preface

The Readiness, Implementation, and Management Plans (RIMPs) have been created to document the analysis techniques, methodology, duration, tools, data, resources, staffing, and schedule of the Post-Launch Product Tests (PLPTs) to be used by the calibration and validation (cal/val) science teams to demonstrate the different levels of product maturity. The primary purpose of the RIMPs is to act as a planning resource for the cal/val teams as they prepare for Launch. Additionally, the RIMPs can be used by other members of the GOES-R Program to prepare for cal/val activities, to assess the suitability of the cal/val test plans, and to understand the science teams' data and resource requirements. Cal/val testing is likely to reveal necessary algorithm and/or look-up table (LUT) changes to evolve the product quality through the maturity levels. The Algorithm Change Management Plan (ACMP) will be used to track and implement these algorithm changes.

The evolving cal/val maturity of GOES-R products throughout the beginning of the mission is described by three levels: Beta, Provisional, and Full Validation. The Flight Project is responsible for producing the Level 1b (L1b) products according to the GOES-R Level III requirement documents. Once Beta maturity of the L1b products is achieved, validation activities for Level 2+ (L2+) products can begin[1]. Further levels of maturity (Provisional and Full Validation) require additional and often long-term activities. A detailed description of the three product maturity levels is given in Figure 1, but a brief description of the three maturity levels are:

> **Beta:** the product is minimally validated and may still contain significant errors; based on product quick looks using the initial calibration parameters.
>
> **Provisional:** product performance has been demonstrated through a select number of independent measurements and periods. The analysis is sufficient to communicate product performance to end users, and the product is ready for operational use.
>
> **Full:** product performance has been demonstrated over a large and wide range of representative conditions, with comprehensive documentation of product performance, including known anomalies and their remediation strategies. The product is operational.

Product quality assessment and declaration of maturity levels is performed during Peer Stakeholder–Product Validation Reviews (PS-PVRs). At each PS-PVR, the status of products will be presented by members of the cal/val science teams. For L1b products, Beta maturity PS-PVRs are held once each instrument's Post-Launch Tests (PLTs) have been successfully completed by the GOES-R Flight Project and the instrument vendors. Note that for GOES-18 and GOES-19, Beta maturity will be declared based on the quality assessment needed for the first public image/data release. After an L1b product has achieved Beta maturity, the product is added to the GOES Rebroadcast (GRB) stream. After an L1b or L2+ product has achieved Provisional maturity, the product is approved for distribution from Product Distribution and Access (PDA) and Comprehensive Large Array-data Stewardship System (CLASS). The review panel at the PS-PVRs will include the GOES-R Operational Readiness Working Group (GORWG), GOES-R

[1] Because the GLM L1b product is not distributed like the other GOES-R Series instrument L1b products, the distributed GLM L2 product follows the L1b product maturity validation schedule and distribution methods.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Program System Engineering (PSE), NOAA Office of Satellite and Product Operations (OSPO), National Weather Service (NWS), and GOES-R Product Readiness and Operations (PRO). PS-PVR artifacts will be publicly available at https://www.noaasis.noaa.gov/GOES/product_quality.html.

The introspection necessary to create these RIMPs has led to extensive consultations between the cal/val teams and other groups within the GOES-R Program, including Program System Engineering, the Flight Project and the Ground Segment. Figure 2 below describes the responsibilities and accountability of each of the main parties involved in the creation of the RIMPs. This delineation is required because GOES-R operations are to be handed over from the GOES-R Program to NOAA OSPO at the end of the PLT period, yet the process of validating product maturity will continue. This changing nature of accountability during the process must be acknowledged. Accountability of the RIMPs changes at Operations Handover from NASA to NOAA and is aligned with the level of each RIMP's validation maturity objective. Accountability describes which organization owns documentation, process, and procedures. Responsibility describes which organization creates, executes, and maintains specific activities.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

GOES-R Product (L1b and L2+) Maturity Levels

Beta Validation

Preparation Activities
- Initial calibration applied (L1b).
- Rapid changes in product input tables, and possibly product algorithms, can be expected.
- Product quick looks and initial comparisons with ground truth data (if any) are not adequate to determine product quality.
- Anomalies may be found in the product and the resolution strategy may not exist.

End State
- Products are made available to users to gain familiarity with data formats and parameters.
- Product has been minimally validated and may still contain significant errors.
- Product is not optimized for operational use.

Provisional Validation

Preparation Activities
- Validation and quality assurance (QA) activities are ongoing, and the general research community is now encouraged to participate.
- Severe algorithm anomalies are identified and under analysis. Solutions to anomalies are in development and testing.
- Incremental product improvements may still be occurring.
- Users are engaged in the Customer Forums (L2+ products only), and user feedback is assessed.

End State
- Product performance (L1b or L2+) has been demonstrated through analysis of a small number of independent measurements obtained from selected locations, periods, and associated ground-truth/field program efforts.
- Product analysis is sufficient to communicate product performance to users relative to expectations.
- Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.
- Testing has been fully documented.
- Product ready for operational use and for use in comprehensive calibration/validation activities and product optimization.

Full Validation

Preparation Activities
- Validation, QA, and anomaly resolution activities are ongoing.
- Incremental product improvements may still be occurring.
- Users are engaged and user feedback is assessed.

End State
- Product performance for all products is defined and documented over a wide range of representative conditions via ongoing ground-truth and validation efforts.
- Products are operationally optimized, as necessary, considering mission parameters of cost, schedule, and technical competence as compared to user expectations.
- All known product anomalies are documented and shared with the user community.
- Product is operational.

Figure 1. GOES-R product maturity levels.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

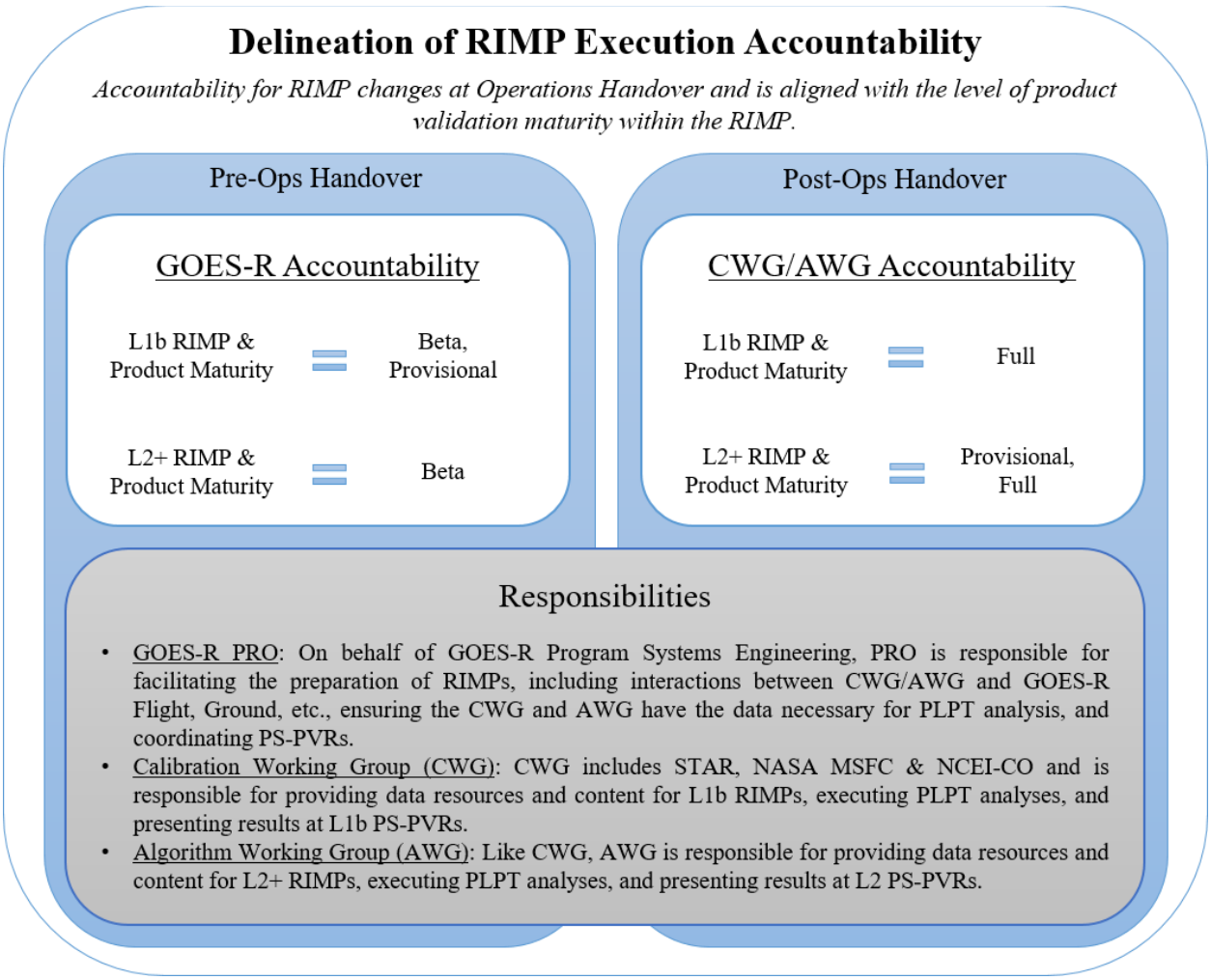

Figure 2. Delineation of RIMP execution accountability between GOES-R and CWG/AWG.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

1. GLM Validation Overview

This document supplements Program-level documents that provide a high-level overview of calibration and product validation associated with all GOES-R instruments and through all lifecycle phases. This document focuses on the management and implementation of GOES-R Level 1b / Level 2 (L1b/L2) Post-Launch Tests (PLTs) and Post-Launch Product Tests (PLPTs) and their preparation activities that apply or impact the validation of the GLM product science quality. PLT activities are organized, documented, and executed by the Flight Project. PLPT readiness, implementation, and management plans comprise the main focus of this document.

The GLM L1b product is a non-distributed intermediate product which consists of calibrated, geolocated events (pixel-level optical energy that meets or exceeds GLM instrument threshold). The distributed L2 products are events, groups, and flashes that have been characterized in terms of their correspondence to lightning detected by other instruments, ground-based arrays, and fully characterized space- or airborne instruments. Because the GLM L1b product is not distributed like the other GOES-R Series instrument L1b products, the distributed GLM L2 product follows the L1b product maturity validation schedule and distribution methods.

PLT activities are led by Flight and designed to demonstrate that the vendor-delivered instrument meets contractual performance requirements, and products will be characterized during the PLPT phase. The PLPT phase occurs after the initial post-launch activation and characterization testing shows that GLM products have reached Beta maturity. The primary goal of the PLPT phase is to advance the level of product validation maturity from Beta to Provisional prior to the Handover to Operations. Determination of Provisional product validation status will be assessed based on post-launch data available at the end of scheduled testing. While nominal operational performance is anticipated during the PLPT phase, the tests are necessary to ensure proper on-orbit product performance and to identify, report, and characterize anomalous results.

The PLPTs required for Provisional and Full Validation are listed in Table 2, with each test's details provided in Appendix A. Within each entry in Appendix A, the entry "Reference MRD" gives the reference numbers from the Mission Requirements Document (MRD). The performance baseline given by Massachusetts Institute of Technology – Lincoln Laboratory (MIT LL) demonstrates how these MRD requirements were verified pre-launch. The objective of the testing described in this RIMP is to re-certify the pre-launch performance baseline and to determine through instrument characterization if the deliverable products satisfy their intended use in the intended environment. Therefore, the expectation is for the science teams to execute PLPTs necessary and sufficient to perform this re-certification objective to the best of their ability. The references to specific MRD requirements are provided as justification for including each PLPT in the cal/val effort. These references are based on the analysis and recommendations of MIT LL and The Aerospace Corporation subject matter experts. The listing of MRD items does not fully enumerate the possible results from each PLPT, including those that may address other Performance Baseline results, but are the priority items according to the science team. Due to the limitations of post-launch testing, it may be difficult, if not impossible, to characterize some products or product characteristics to the same precision and accuracy as the performance baseline.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Post-Launch Test Activities

The PLTs that support Beta maturity are listed in Table 1. Some instrument-related PLTs (e.g., setting GLM Real Time Event Processor [RTEP] thresholds) must be completed before Detection Efficiency (DE) and False Alarm Rate (FAR) related PLPTs can be initiated (Note that throughout this document, DE refers to Flash Detection Efficiency, and FAR refers to Flash False Alarm Rate). DE and FAR cannot be correctly assessed in the PLPT process if RTEP thresholds are not set properly. However, there should also be flexibility in that thresholds can be tentatively set, then DE and FAR-related PLPTs run to make assessments, then RTEP thresholds re-set accordingly. This back-and-forth "tuning process" is vital for thoroughly optimizing the GLM.

Table 1. Beta Validation PLT test IDs, short titles, and execution status per satellite. Blue color denotes test was / will be done. Gray shading indicates test was not / will not be done, or is a reserve test. Stars (*) in the Test IDs are placeholders for the satellite number (i.e., 16, 17, 18, or 19).

Test ID	Short Titles	16	17	18/19
G*-C-GLM-001	Validate GLM Timing Settings and Image Quality			
G*-C-GLM-002	Set GLM RTEP Thresholds			
G*-C-GLM-003	Set GLM Second Level Thresholds			
G*-C-GLM-004	Validate GLM GPA Parameters			
G*-R-GLM-006	Verify Solar Intrusion Criteria			
G*-C-GLM-007	On Orbit Calibration			
G*-C-GLM-008	Event Filtering Cross Satellite Comparison			
G*-E-GLMINR-001	GLM Coastline ID INR Characterization Assessment			
G*-E-GLMINR-002	GLM Event Navigation Coarse Characterization Assessment			
G*-P-GLMINR-003	GLM Background INR Performance Assessment			
G*-R-GLMINR-004	GLM Alignment Assessment			
G*-E-GLMINR-005	GLM Navigation Cross Satellite Comparison			

Post-Launch Product Test Activities

The PLPTs that support GLM are categorized into different series as listed in Table 2. Criteria are the same for PLPTs that support each maturity level except with respect to dependencies. Where 10 flashes are required for Beta, 100 flashes are required for Provisional, and 1000 flashes are required for Full maturity. See Appendix A for each test's details.

It is important to keep in mind that lightning may not occur, or is very infrequent, in a particular region (e.g., the South Pacific is a notable region of low flash density because it is an oceanic region outside of the intertropical convergence zone [ITCZ]). In such cases, boot-strapping/extrapolative methodologies are the only viable alternative for accessing GLM performance in the region. Therefore, not all regions will be rigidly held to the fixed flash count values required for each product maturity level.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Table 2. PLPT series ID, short title, and execution status for each satellite (GOES-16, -17, and -18/-19), with a "B" indicating the test is required (or was done) for Beta maturity, a "P" indicating the test is required (or was done) for Provisional maturity, and an "F" indicating the test is required (or was done) for Full maturity. An "R" indicates the test is a reserve test.

Series ID	Series Short Titles	16	17	18/19
GLM_L2_001	Validate GLM Detection Efficiency (DE) and False Alarm Rate (FAR) using Well Characterized Medium to Long Range Networks with Medium to High Detection Efficiencies and Low False Alarm Rates	**B, P, F**	**B, P, F**	**P, F**
GLM_L2_002	Validate GLM DE and FAR using Well Characterized Short Range Networks with High Detection Efficiencies and Low False Alarm Rates	**B, P, F**	**B, P, F**	**P, F**
GLM_L2_003	Validate GLM Storm Detection Efficiency (SDE) and Storm False Alarm Rate (SFAR) using Well Characterized Very Long Range Systems with Low (to no) Flash Detection Efficiencies but Medium Storm Detection Efficiencies	**B, P, F**	**B, P, F**	**F**
GLM_L2_004	Validate GLM DE and FAR using Well Characterized Very Short Range Optical Systems with Very High Flash Detection Efficiencies and Low False Alarm Rates	**B, P, F**	**R**	**R**
GLM_L2_005	Validate GLM DE and FAR using Well Characterized Orbital Based Optical Systems with High Flash Detection Efficiencies and Low False Alarm Rates	**B, P, F**	**B, P, F**	**P, F**
GLM_L2_006	Validate GLM DE and FAR using Well Characterized Ground Based Electric Field Networks with High Flash Detection Efficiencies and Low False Alarm Rates	**B, P, F**	**B, P, F**	**P, F**
GLM_L2_009	Validate GLM L1b-L2 Cluster/Filter Algorithm Using Specification (Spec) Code and Comparing Outputs	**B, P, F**	**B, P, F**	**P, F**
GLM_L2_010	Validate GLM L0-L1b Filter Algorithms Using Spec Code and Comparing Outputs	**B, P, F**	**B, P, F**	**P, F**
GLM_INR_011	Validate GLM INR With Comparisons to Well Located Ground Points	**B, P, F**	**B, P, F**	**P, F**
GLM_RAD_012	Validate GLM Background Deep Convective Cloud Radiances and Radiance Trending With Comparisons to Other Measures of Background Radiances	**B, P, F**	**B, P, F**	**P, F**
GLM_RAD_013	Validate GLM Event Energies and Energy Trending With Comparisons to Other Measures of Event Energy	**B, P, F**	**B, P, F**	**P, F**

The same PLPT series have been executed for each maturity level for GOES-16 and GOES-17, but for GOES-18 and GOES-19 there are two differences: Beta PLPTs will not be executed, and PLPT series GLM_L2_003 will only be reported for Full maturity. GLM_L2_004 was only required for GOES-16 and will continue as a reserve test for subsequent satellites, only reported if a field campaign takes place.

PLPT series 007 (Validate and Tune GLM L0-L1b Filter Parameters) was withdrawn since it was considered more appropriate to be handled by the instrument vendor. It should be noted that additional assessment during PLPT activities may provide insight for further threshold and filter parameter tuning. Series 008 (Validate GLM Continuing Current Detection Mode) was withdrawn because the continuing current detection mode will likely not be used.

With regard to the GLM_RAD_012 series and GLM_RAD_013 series, attaining Full maturity involves obtaining baseline values of GLM background Deep Convective Cloud Radiances and GLM optical event energies, respectively, so that these baselines can be used as a fundamental reference in the long-term trending of these parameters during the operational phase.

In addition to assessing basic GLM instrument performance and degradation, all of the PLPTs listed will be used to assess (either directly or indirectly) the fluctuations in GLM instrument performance due to stray light impacts (i.e., as from the so called optical "arcs" and "blobs" that are expected to traverse the Charge Coupled Device [CCD] array during/near eclipse during the equinox season). The PLPTs will also be used to help assess and document any impacts that are suspected to be related to the uncertainties in instrument gain, particularly as these uncertainties might affect DE.

The validation processes and procedures, monitoring and analysis methods, tools, and expected output artifacts are described in the following sections. The details of each PLPT are contained in Appendix A and of each reference data set are in Appendix B. The details of each PLT are in Appendix C and any tools used in the validation process are in Appendix D.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

2. Schedule of Events

The nominal post-launch validation schedule for all GOES-R Series products is shown in Figure 3. Table 3 breaks down the schedule specifically for the GLM product for all satellites in the GOES-R Series.

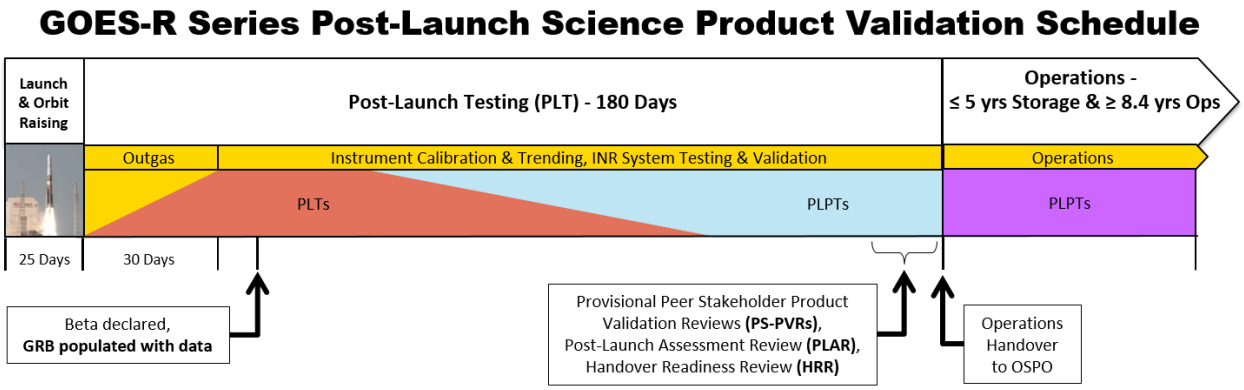

Figure 3. The post-launch validation schedule.

Table 3. Post-launch science product validation schedule for GLM. The first column shows the nominal schedule in time from launch (L) plus months. The second column shows the same for days. The GOES columns with colored cells denote actual date, while the white cells denote notional date; the values in parentheses show L+days.

	Nominal (months)	Nominal (days)	GOES-16	GOES-17	GOES-18	GOES-19
Launch	L+0	L+0	11/19/16 (L+0)	3/1/18 (L+0)	*12/7/21*	*4/1/24*
Outgas complete	L+1.5	L+45	1/4/17 (L+46)	4/12/18 (L+42)	*1/21/22*	*5/14/24*
Beta	L+3.5	L+105	7/5/17 (L+228)	10/2/18 (L+215)	*3/21/22*	*7/14/24*
Provisional	L+6	L+180	1/19/18 (L+426)	12/20/18 (L+294)	*6/7/22*	*10/1/24*
Full	L+18	L+545	11/1/18 (L+712)	8/20/20 (L+903)	*6/7/23*	*10/1/25*

The following subsections describe the nominal GLM product schedule on the assumption that a satellite is going to operations. The goal is for Beta and Provisional Validation to be completed before Handover to Operations or storage at L+6 months.

2.1 Beta Maturity Testing

For GOES-16 and GOES-17 a Beta PS-PVR was held to show the results of the PLT activities and determine if the product demonstrates on-orbit performance adequate to begin detailed product testing. In lieu of a Beta PS-PVR, for GOES-18 and GOES-19 high priority PLT results used in preparation of the first public image will be substituted for a Beta Certification.

2.1.1 Beta Entrance Criteria: Completion of launch, orbit raising, and outgassing, expected by L+45 days.

2.1.2 Duration of Beta Testing: The Flight- and vendor-led PLT activities begin during the Beta phase and have been scheduled for completion by L+210 days. However, for GOES-18 and GOES-19 the Beta duration will be streamlined and expected to be complete by L+180 days. Although Beta Certification will be given with the release of the first public image at L+105 days, the PLT activities will continue beyond this point into the PLPT period.

2.1.3 Beta Testing Artifacts: The PLT reports will be generated by the Flight and vendor teams. These will be discussed at the Post Test Data Review (PTDR) meetings and stored on the GOES-R portal.

2.1.4 Exit Criteria and Readiness for Beta Certification: The general criterion for Beta product maturity is that the product has demonstrated on-orbit performance adequate to begin detailed product testing, but in most cases this includes having RTEP thresholds tentatively set. Specific criteria for completing the PLT tests necessary for establishing Beta maturity are described in the PLT forms.

2.2 Provisional Maturity Testing

Initial testing will focus on determining whether GLM is finding lightning where lightning is expected and not finding lightning where there should be no lightning. Testing will then focus on making the first actual measurements of the GLM DE and FAR. All appropriate PLPTs will be eligible for activation, depending on the availability of lightning data within the GLM field of view (FOV).

Because the occurrence of lightning is out of the control of the GLM team, PLPTs will be activated on a “target of opportunity” basis. The main priority will be intercomparisons between on-orbit GOES-R Series GLM flight models with overlapping FOVs. Field program based PLPTs (e.g., using the Fly’s Eye GLM Simulator, FEGS) would also take a high priority due to limited time/location of field program data collection.

Priority will be given to PLPTs in this general order:

1. PLPTs that compare on-orbit GOES-R Series GLM flight models with overlapping FOVs
2. Ground truth systems that are optically based (e.g., FEGS aircraft field campaign effort, ISS-LIS)

3. Regions with no prior PLPT lightning (both temporal and spatial)
4. Ground truth systems with the highest DE, lowest FAR for total lightning

2.2.1 Provisional Entrance Criteria: PLPT activities begin during Flight-led PLT activities - after RTEP thresholds have been tentatively set.

2.2.2 Duration of Provisional Testing: The schedule on a PLPT by PLPT basis is flexible since scheduling largely depends on opportunity (i.e., where and when lightning is occurring). Provisional testing is scheduled for completion and the Provisional PS-PVR held by L+180 days.

2.2.3 Provisional Testing Artifacts: Report containing an introduction, GLM overview, figures/tables that summarize GLM comparisons with reference validation datasets, and initial calculations of GLM DE and FAR. An update should also be given on whether the RTEP thresholds are converging or finished being set by the time of the Provisional PS-PVR.

2.2.4 Exit Criteria and Readiness for Provisional PS-PVR: 100 flashes required for Provisional PLPT analyses, and report prepared for delivery.

2.3 Full Maturity Testing

Full Validation testing will augment the analyses done for Provisional by increasing the confidence levels for the validations with even more data points.

2.3.1 Full Entrance Criteria: Data are Provisionally mature. If the satellite has gone into storage immediately after Provisional Validation, Full maturity PLPTs will start after the satellite is moved out of storage location.

2.3.2 Duration of Full Testing: One year of testing with Provisional data is the nominal duration for Full maturity validation, although for GOES-16 GLM, less than one year of data was needed.

2.3.3 Full Testing Artifacts: Report containing an introduction, GLM overview, figures/tables that summarize comprehensive GLM comparisons with reference validation datasets, GLM initial output, and calculations of GLM DE and FAR. Other data results will include GLM Storm Detection Efficiency (SDE), and trending with Deep Convective Cloud (DCC) pixel values and GLM event energies.

Exit Criteria and Readiness for Full PS-PVR: 1000 flashes required for Full PLPT analyses, and report prepared for delivery. Product performance is defined, product is operationally optimized, and all known product anomalies are documented and shared with the user community. Full Validation is expected by L+545 days if the satellite is not placed into storage.

3. Roles and Responsibilities

The GOES-R Calibration/Validation Plan Volume 1: L1b Data (cal/val plan) is the governing document defining organizational responsibilities for GOES-R product testing, including the analysis, review, approval, and anomaly resolution processes required for product validation. The cal/val plan takes precedence over the following summary of specific post-launch test responsibilities.

PLT assessments of GLM instrument functionality, non-nominal operations, and initial data quality are conducted by the MOST with vendor support by Lockheed Martin. GLM will achieve Beta Validation during these early PLT assessments. Subsequent PLPT activities to advance product maturity to Provisional Validation involves detailed data analysis conducted under guidance of the CWG and GOES-R Program management by members of the cal/val team at NOAA, NASA, and industry. The roles and responsibilities of specific individuals and organizations during each satellite's PLT period are listed in Table 4 (names and affiliations subject to change).

Table 4. GLM roles and responsibilities

Role	GOES-16	GOES-17	GOES-18/19
GLM PLPT Lead	Douglas Mach (USRA)	Douglas Mach (USRA)	Douglas Mach (USRA)
Field Campaign	Francis Padula (PSE)	Steve Goodman (GOES-R)	Steve Goodman (GOES-R)
GOES-R Product Quality Lead	Wayne MacKenzie (PRO); Jon Fulbright (PRO)	Elizabeth Kline (PRO)	Elizabeth Kline (PRO)
Ground Segment Product Readiness and Operations Cal/Val Coordination	Jon Fulbright (PRO; alternate: Elizabeth Kline)	Jon Fulbright (PRO; alternate: Elizabeth Kline)	Jon Fulbright (PRO; alternate: Elizabeth Kline)
PLT Test Engineer(s)	Jennifer Dodd (MOST); Samantha Edgington (LM)	Abigail Iacangelo (MOST); Samantha Edgington (LM)	Gabe Gonzalez (MOST); Tewa Kpulun (LM)
GLM Product Quality Feedback	William Koshak (MSFC); Scott Rudlosky (STAR)	William Koshak (MSFC); Scott Rudlosky (STAR)	William Koshak (MSFC); Scott Rudlosky (STAR)
ERB Rep	Elizabeth Kline (PRO)	Elizabeth Kline (PRO)	Elizabeth Kline (PRO)
Remote Access	Ryan Williams (PRO); Jon Fulbright (PRO)	Janet Larson (PRO)	Janet Larson (PRO)

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

PASS/eGRES Requests	Wayne Mackenzie (PRO)	Stephen Superczynski (PRO)	Stephen Superczynski (PRO)
Flight Coordination	Jeff Kronenwetter (Flight)	Jemma Kline (Flight)	Melissa Dahya (Flight)
PLT SOE CR Contact	Mike Otero (Flight)	Andrew Lyashko (Flight)	Denis Pinha (Flight)

4. Tools

As an overview, there are several software tools that will be used to evaluate the GLM, provided below (see Appendix D for additional details):

- VaLiD (Validate Lightning Data) tool, written in the C programming language, and developed by Dr. Monte Bateman of the Universities Space Research Association (USRA), will be run by the AWG/CWG Huntsville, AL group to perform shallow and deep dives of the GLM data using a wide range of ground-based datasets discussed in this RIMP document.
- Cluster/Filter tool, written in Matlab programming language, and developed by Dr. Doug Mach of USRA, will be used to conduct in-house L0-L1b and L1b-L2 processing.
- HAMMA User Data Analysis Technology (HUDAT), written in the IDL programming language, and developed by Dr. Phillip Bitzer of the University of Alabama in Huntsville (UAH), will be used to examine various characteristics of lightning with special emphasis on lightning energetics. This tool uses the Huntsville Area Marx Meter Array (HAMMA).
- STorm Retrievals frOm KSC E-Fields (STROKE), written in the IDL programming language, and developed by Dr. William Koshak of NASA/Marshall Space Flight Center (MSFC), will be used (only under special circumstances) to examine ground-based electric fields, lightning field changes, and the charges deposited by lightning from all thunderstorms in the Kennedy Space Center (KSC) Florida region.
- INR/Parallax tool, written in the IDL programming language, and developed by Mr. Dennis Buechler of UAH, will be used to validate GLM INR. It will make comparisons to well-located ground points and employs GLM background images & lightning, Advanced Baseline Imager (ABI) background images, and laser beacon data.
- Trending Tool for Deep Convective Clouds (TT/DCC) analyses, written in IDL, and developed by Mr. Dennis Buechler of UAH, will be used for long-term trending of DCC.
- Trending Tool for Lightning (TT/Lightning) analyses, written in IDL, and developed by Dr. William Koshak of NASA/MSFC, will be used for long-term trending of lightning counts (event, group, and flash counts), flash duration, and lightning signal amplitude.
- Product Monitor (PM; the GLM component is also known as the Lightning Monitoring Tool (LMT)) will be run by contractor staff at the NOAA Satellite Operations Facility (NSOF) under the guidance of the Product Area Lead (PAL). This tool continuously monitors product quality and metrics for all GOES-R Series instruments, with the LMT alerting operators if any GLM lightning data (e.g., detection efficiency) look problematic. If any problematic occurrences in the data cannot be resolved by the NSOF staff and PAL, they will further consult with the vendor and/or the AWG/CWG groups in Huntsville, AL for further “deep dive” analyses.
- CompareLLS (Compare Lightning Location System) tool, written in the Matlab programming language, and developed by Dr. Ken Cummins of the University of Arizona, will be used to perform shallow and deep dives of the GLM data using a wide range of ground-based datasets discussed in this RIMP document.
- X Lightning Mapping Array (XLMA) tool, written in the IDL programming language, and developed by Drs. Paul Krehbiel and Bill Rison of New Mexico Tech, will be used to perform detailed analyses of Lightning Mapping Array (LMA) data.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

- lmatools, written in the Python programming language, and developed by Dr. Eric Bruning of Texas Tech University, will be used to perform several functions related to LMA data [i.e., sort VHF source data into flashes; calculate flash areas, volumes, and channel lengths using a convex hull-based method; produce gridded products (flash extent density, flash invitation density, average flash area, VHF source density) derived from flashes; calculate time series statistics of flash rate and size data using storm cell polygons; simulate LMA performance characteristics].
- Fly's Eye GLM Simulator Tool (FEGST), written in IDL, and developed by Drs. Mason Quick and Rich Blakeslee of NASA/MSFC will be used to analyze FEGS data and help compare it with other lightning optical datasets (e.g., GLM, ISS/LIS); some of these processing tools will be piggybacked to VaLiD. This activity is central to the aircraft field campaign validation effort.
- Ancillary Dataset Tools (ADTs), written using Matlab or simple McIDAS scripts, and developed by Drs. Doug Mach and Monte Bateman of USRA, will be used for processing datasets such as NEXt-generation RADar (NEXRAD), Spinning Enhanced Visible and Infrared Imager (SEVERI), ABI (especially cloud top height for parallax analyses), and World Wide Lightning Locating Network (WWLLN); some of these tools will be piggybacked to VaLiD.
- Specialized Impromptu Tools (SITs), written "on-the-fly" in various possible programming languages (e.g., Matlab, IDL, C, Mathematica) will be used to handle any analyses that are needed, but that were unexpected. Code developers for these possible tools include Drs. Mach & Bateman of USRA, Dr. Buechler (UAH), and Dr. Koshak (NASA/MSFC).
- Location And Time Accuracy (LATA) Tool, written in Matlab, and developed by Dr. Katrina Virts (NPP/MSFC), will be used to produce a variety of plots/histograms that characterize the overall location/time accuracy of GLM flashes/groups/events.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

5. Pre-launch

The Information Technology & Systems Center (ITSC) at the University of Alabama in Huntsville provides the GLM L0 local storage capability within the National Space Science & Technology Center (NSSTC). The ITSC also provides a "one-stop shop" portal for the GOES-R GLM Field Campaign and GLM calibration/validation data. The portal offers tools and services that leverage existing Global Hydrology Resource Center (GHRC) skills and processes. The password protected portal supports collaboration planning and coordination including project coordination documents (e.g., science plan, logistics, meeting minutes, presentations, shared flight plans, weather forecasts), access to ancillary data and quick looks during campaigns, and reports on mission science, project, and instrument status. Overall data management is key, with support for science data product acquisition, documentation, visualization, distribution, and publication. The initial (FY16) L0 storage capacity of 100 TB was procured, and in place as of August 2016. Expansion of the storage by an additional 100 TB was planned in FY2018. Annual projected data volume is 64 TB (= 32 TB/year/instrument × 2 operational GLM instruments).

In preparation for the GOES-R (now GOES-16) launch, the AWG/CWG Huntsville group formally exercised its local Data Management System (DMS) in coordination with the GOES-R PAL and the ITSC beginning in late October 2016. However, several less formal Ground Readiness Exercises (GREs) were conducted (GRE DO-1 5-11 Oct 2015; GRE DO-2 Jan/Feb 2016; GRE DO-3 May 2016) to gain additional insight and assess weak spots. A primary input test dataset used for these simulated pre-launch data exercises was the Mission Validation Test Data Set (MVTDS). The MVTDS contains GOES background imagery data with overlaid lightning optical data. The lightning optical data is simulated using Grandell statistics of TRMM/LIS heritage data. The MVTDS is a 2 hour loop of data with variable background imagery, but the lightning data consists of a 1 minute loop that repeats 120 times to fill the 2 hour interval. In addition, between June and September 2016, several performance tests were conducted to exercise the interface between Level Zero Storage System (LZSS) and local GLM data system with simulated GLM L0 data, as well as a series of Environmental Satellite Processing and Distribution System (ESPDS) Product Distribution and Access (PDA) Validation Tests with multiple simulated data streams from GOES-R/16 and GOES-S/17.

Beyond GOES-16, simulated data is no longer used for pre-launch testing. Instead, data from an on-orbit flight model is run through the ground system to ensure that the data is labeled as if it is from the new flight model, that the science teams can receive the data, and that their tools can process the newly labeled data. Data exercises prior to the GOES-T launch include End-To-End (ETE) tests beginning in late-2020 and Data Operations Exercises (DOE) in the first half of 2021. Some DOEs will contain data useful for AWG/CWG evaluation purposes.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

6. References

The following documents have information relevant to this RIMP document. Unless otherwise noted, all documents with a "410-R" or "417-R" prefix are located in the GOES-R Library (in the Windchill repository). All other government documents can be found in the GOES-R Portal at https://goesportal.ndc.nasa.gov/.

Unless otherwise noted, the current versions of the following documents apply.

1. 410-R-CALVAL-0192, GOES-R Series Calibration and Product Validation Strategy
2. 410-R-MRD-0070, GOES-R Series Mission Requirements Document (MRD)
3. 410-R-CONOPS-0008, GOES-R Series Concept of Operations (CONOPS)
4. 410-R-PLN-0101, GOES-R Series Calibration/Validation Plan Volume 1: Level 1b Data
5. 410-R-PLN-0194, GOES-R Series Calibration/Validation Plan Volume 2: Level 2+ Product Validation
6. 417-R-PLN-0246, GOES-R Series Post-Launch Testing (PLT) Plan
7. GOES-R PLT and Active PLPT Forms on the GOES-R Program Portal:
Repository > 01 GOES R > 02 GOES R - Flight Project > 04 Mission Operations > 900 CM Docs > 935 PLT - GOES-R
Repository > 01 GOES R > 02 GOES R - Flight Project > 04 Mission Operations > 900 CM Docs > 936 PLT - GOES-S
Repository > 01 GOES R > 02 GOES R - Flight Project > 04 Mission Operations > 900 CM Docs > 937 PLT - GOES-T
8. GOES-R Passive L1b PLPT Forms on the GOES-R Program Portal:
Repository > 01 GOES R > 02 GOES R - Flight Project > 04 Mission Operations > PLT > GOES-18 Passive PLPT forms
9. Mach, D. M. (2020). Geostationary Lightning Mapper clustering algorithm stability. *Journal of Geophysical Research: Atmospheres*, 125, e2019JD031900. https://doi.org/10.1029/2019JD031900
10. Bateman, M., and D. Mach (2020). Preliminary detection efficiency and false alarm rate assessment of the Geostationary Lightning Mapper on the GOES-16 satellite. *Journal of Applied Remote Sensing*, 14(3), 032406. https://doi.org/10.1117/1.JRS.14.032406

A. Appendix A: Post-Launch Product Tests

The point of contact for each PLPT is the CWG unless otherwise specified in the individual test.

A.1 PLPTs that support BETA Validation maturity

None – Only PLTs are required for Beta Validation maturity.

A.2 PLPTs that support PROVISIONAL Validation maturity

A.2.1 GLM_L2_001 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM DE and FAR using well characterized medium to long range networks with medium to high detection efficiencies and low false alarm rates
Reference MRD: 1259, 1261
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): GLM L2 flashes
General Success Criteria: If the GLM detects at least 70% of the flashes identified by the medium to long range networks and locates those flashes to within the coarser GLM location uncertainty, the GLM will have met success criteria for this test.
Provisional Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 100, these PLPTs will contribute to the Provisional Validation level.

Note: Since these networks identify and detect intracloud (IC) flashes with lower and variable detection efficiencies, any flashes that GLM detects, but are not detected by the networks will NOT directly contribute to the false alarm rate of GLM. Further analysis of the data including other PLPTs will be required to fully determine the DE and FAR for GLM.

Dependencies: 100 flashes detected (day & night)
Validation Data: Medium to long range lightning detection networks
PLPTs in this series:

- GLM_L2_001a – ATDNet (Arrival Time Difference NETwork)
- GLM_L2_001b – BrazilDAT (Sistema Brasileiro de Detecção de Descargas Atmosféricas)
- GLM_L2_001c – CLDN (Canadian Lightning Detection Network)
- GLM_L2_001e – ENTLN (Earth Networks Total Lightning Network)
- GLM_L2_001g – GLD360 (Vaisala Global Lightning Dataset)
- GLM_L2_001l – LINET (LIghtning detection NETwork): national network
- GLM_L2_001n – NLDN (National Lightning Detection Network)
- GLM_L2_001r – RINDAT (Rede Integrada Nacional de Detecção de Descargas Atmosféricas)
- GLM_L2_001s – STARNet (Sferics Timing And Ranging NETwork)

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Monitoring & Analysis Method: Use the near real-time network data with VaLiD to compare the flash locations and times with those found by GLM. Data collected via the internet.
Tools Needed: VaLiD, CompareLLS, SITs, and other routine in-house lightning analysis tools.

A.2.2 GLM_L2_002 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM DE and FAR using well characterized short range networks with high detection efficiencies and low false alarm rates
Reference MRD: 1259, 1261
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): GLM L2 flashes
General Success Criteria: If the GLM detects at least 70% of the flashes identified by the short range networks and locates those flashes to within the coarser GLM location uncertainty, the GLM will have met success criteria for this test.
Provisional Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 100, these PLPTs will contribute to the Provisional Validation level.

Note: These systems do not detect the same electromagnetic spectrum as GLM, therefore, any flashes that GLM detects, but are not detected by the networks will NOT directly contribute to the false alarm rate of GLM. Further analysis of the data including other PLPTs will be required to fully determine the DE and FAR for GLM.

Dependencies: 100 flashes detected (day & night)
Validation Data: Short range lightning detection networks:

- GLM_L2_002a – NALMA (North Alabama Lightning Mapper Array)[&#]
- GLM_L2_002c – TLMA (Toronto Lightning Mapper Array)
- GLM_L2_002d – DCLMA (District of Columbia Lightning Mapper Array)
- GLM_L2_002f – FCLMA (Fort Collins Lightning Mapper Array)
- GLM_L2_002g – NGLMA (North Georgia Lightning Mapper Array)
- GLM_L2_002h – HLMA (Houston Lightning Mapper Array)
- GLM_L2_002k – KSCLMA (Kennedy Space Center Lightning Mapper Array)[&]
- GLM_L2_002n – NMLMA (New Mexico Lightning Mapper Array)[&]
- GLM_L2_002o – OKLMA (Oklahoma Lightning Mapper Array)[&]
- GLM_L2_002t – WTLMA (West Texas Lightning Mapper Array)
- GLM_L2_002w – WILMA (Wallops Island Lightning Mapper Array)

[&] *Note that these networks will each be augmented by a ground-based broadband VHF lightning interferometer network as described in Appendix B, section B.16. The interferometer networks have even higher detection efficiency than the LMA networks, but shorter range (~25 km).*

[#] *Note that the NALMA is augmented with a local 11-station VLF/LF system called LIghtning detection NETwork (LINET) that provides additional details of the discharges; this local network is distinct from the national level (longer baseline) LINET system mentioned above in section A.2.1.*

Monitoring & Analysis Method: Use the near real-time validation data and with VaLiD and compare the flash locations and times with those found by GLM.
Tools Needed: VaLiD, XLMA, lmatools, CompareLLS, SITs, and other routine in-house lightning analysis tools.

A.2.3 GLM_L2_003 series

Required for satellites: 16, 17
Objective: Validate GLM SDE and SFAR using well characterized very long range systems with low (to no) flash detection efficiencies but medium storm detection efficiencies.
Reference MRD: 1259, 1261
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): GLM L2 flashes
General Success Criteria: There is no specific instrument specification for GLM SDE and SFAR; moreover, the fraction of deep convective storms that produce lightning is not well known. Given this context, if the GLM detects any storms identified by these systems and locates those storms to within the GLM location uncertainty, the GLM will have met success criteria for this test. More importantly, this PLPT will help baseline SDE and SFAR so that any substantial changes in these parameters over long-term can be discerned and flagged.
Provisional Success Criteria: If the GLM detects storms and locates those storms to within the GLM location uncertainty, and the SDE and SFAR are within family over the whole GLM FOV, the GLM will have met success criteria for this test.

Note: If the number of storms detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 20, these PLPTs will contribute to the Provisional Validation level. It is possible that deep convection will not have lightning, so estimates of SDE and SFAR are fundamentally limited. Nonetheless, this series of PLPTs provides a coarse, quick, first-look characterization of GLM performance.

Dependencies: 20 storms detected (day & night)
Validation Data: Very long range systems:

- GLM_L2_003a – ABI (Advanced Baseline Imager)
- GLM_L2_003n – NEXRAD (NEXt-generation RADar)
- GLM_L2_003s – SEVERI (Spinning Enhanced Visible and Infrared Imager)
- GLM_L2_003w – WWLLN (World Wide Lightning Locating Network)

Monitoring & Analysis Method: Use the near real-time validation data with VaLiD and compare the storm locations and times with those found by GLM.
Tools Needed: VaLiD, ADTs, SITs, and other routine in-house lightning analysis tools.

A.2.4 GLM_L2_004 series

Required for satellites: 16
Objective: This PLPT is central to a ~6 week two phase aircraft field campaign validation effort that will employ an advanced Fly's Eye GLM Simulator (FEGS) instrument to make detailed observations of the multiply scattered cloud-top optical emissions from lightning. Hence, this series validates GLM DE and FAR using a well characterized very short range optical system with very high flash detection efficiencies and low false alarm rates. Note that

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

while this test was only required for GOES-16, if field campaign data are available for subsequent satellites, then the validation analysis should be shown during the PS-PVR.
Reference MRD: 1259, 1261
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): GLM L2 flashes
General Success Criteria: If the GLM detects at least 70% of the flashes identified by FEGS and locates those flashes to within the coarser GLM location uncertainty, the GLM will have met success criteria for this test.
Provisional Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 100, these PLPTs will contribute to the Provisional Validation level.

Note: Since the FEGS identifies and detects intracloud (IC) and cloud-to-ground (CG) flashes with similar detection efficiencies, any flashes that GLM detects, but are not detected by the FEGS will contribute to the FAR of GLM. This test can directly determine the GLM DE and FAR within the small area covered by the FEGS FOV.

Dependencies: 100 coincident GLM and FEGS lightning observations.
Validation Data: Very short range optical systems

- GLM_L2_004a – FEGS (Fly's Eye GLM Simulator)

Monitoring & Analysis Method: Intercompare the GLM flash locations, times, and optical amplitudes with those found by FEGS.
Tools Needed: VaLiD, FEGST, ADTs, SITs, and other routine in-house lightning analysis tools.

A.2.5 GLM_L2_005 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM DE and FAR using well characterized orbital based optical systems with high flash detection efficiencies and low false alarm rates
Reference MRD: 1259, 1261
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): GLM L2 flashes
General Success Criteria: If the GLM detects at least 70% of the flashes identified by the orbital optical systems and locates those flashes to within the GLM location uncertainty, the GLM will have met success criteria for this test.
Provisional Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 100, these PLPTs will contribute to the Provisional Validation level.

Note: Since these systems identify and detect intracloud (IC) and cloud-to-ground (CG) flashes with similar detection efficiencies, any flashes that GLM detects, but are not detected by these optical systems will contribute to the FAR of GLM. This test can directly determine the GLM DE and FAR within the small area covered by the orbital optical system FOVs (with the caveat of the possible higher GLM DE).

Dependencies: 100 coincident GLM and space-based lightning observations
Validation Data: Orbital based optical systems

- GLM_L2_005a – ISS-ASIM (International Space Station - Atmospheric-Space Interactions Monitor)

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

- GLM_L2_005g – GOES-R Series GLM
- GLM_L2_005i – ISS-LIS (International Space Station - Lightning Imaging Sensor)
- GLM_L2_005m – MTG-LI (Meteosat Third Generation - Lightning Imager)
- GLM_L2_005t – TARANIS (Tool for the Analysis of RAdiations from lightNIngs and Sprites)

Monitoring & Analysis Method: Intercompare the flash locations, times, and optical amplitudes found from GLM, ISS-LIS, and TARANIS. The priority comparisons will be between on-orbit GOES-R Series GLM flight models with overlapping FOVs. MTG-LI and ISS-ASIM will also be used if available and time permits.
Tools Needed: VaLiD, CompareLLS, SITs, and other routine in-house lightning analysis tools.

A.2.6 GLM_L2_006 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM DE and FAR using well characterized ground based electric field networks with high flash detection efficiencies and low false alarm rates
Reference MRD: 1259, 1261
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): GLM L2 flashes
General Success Criteria: If the GLM detects at least 70% of the flashes identified by the ground based systems and locates those flashes to within the GLM location uncertainty, the GLM will have met success criteria for this test.
Provisional Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 100, these PLPTs will contribute to the Provisional Validation level.

Note: Since the ground-based systems identify and detect intracloud (IC) and cloud-to-ground (CG) flashes with similar detection efficiencies, any flashes that GLM detects, but are not detected by the ground based systems will contribute to the FAR of GLM. This test can directly determine the GLM DE and FAR within the small area covered by the ground based systems.

Dependencies: 100 flashes detected (day & night)
Validation Data: Ground based electric field networks

- GLM_L2_006h – HAMMA (Huntsville Area Marx Meter Array)
- GLM_L2_006k – KSCFMA (Kennedy Space Center Field Mill Array)

Monitoring & Analysis Method: Intercompare GLM flash locations and times with those found by HAMMA (and by KSCFMA if specialized deep dive anomaly resolution is recommended).
Tools Needed: VaLiD, CompareLLS, HUDAT, STROKE (if deep dive recommended), SITs, and other routine in-house lightning analysis tools.

A.2.7 GLM_L2_009 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM L1b-L2 cluster/filter algorithm using spec code and comparing outputs
Reference MRD: 1261, 1264

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): L1b output of GLM (Events)
General Success Criteria: If the GLM operational code is able to produce the same results as the AWG spec code, then the GLM L1b-L2 code will have met success criteria for this test.
Provisional Success Criteria: If the number of flashes processed by the GLM code and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 100, these PLPTs will contribute to the Provisional Validation level.
Dependencies: 100 flashes processed (day & night)
Validation Data: This test will take the L1b output of GLM, process the events with the spec cluster/filter code that the GLM-AWG group produced and compare the output of the spec code with the output of the operational code to verify that the operational code is reproducing the spec code clustering results

- GLM_L2_009c – L1b-L2 Clustering Code

Monitoring & Analysis Method: Take the L1b output stream, run it through the AWG spec algorithm and compare the output using VaLiD with the operational code output.
Tools Needed: VaLiD, Cluster/Filter, SITs, and other routine in-house lightning analysis tools.

A.2.8 GLM_L2_010 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM L0-L1b filter algorithms using spec code and comparing outputs
Reference MRD: 1261, 1264
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): L0 data
General Success Criteria: If the GLM L0-L1b operational code with the individual filter toggled on is able to produce the same results as the GLM L0-L1b code with the individual filter toggled off and an external version of the filter applied, then the GLM L0-L1b code filter will have met success criteria for this test.
Provisional Success Criteria: If the number of flashes processed by the GLM code and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 100, these PLPTs will contribute to the Provisional Validation level.
Dependencies: 100 flashes processed (day and night)
Validation Data: To test the filters, two identical streams of L0 data are to be run through the L0-L1b code. One version has the individual filter off and the other has the individual filter on. The stream with the filter off is then filtered by an external version of the filter. The results with and without the filtered are compared.

- GLM_L1b_010g – Solar Glint Filter Code
- GLM_L1b_010l – Contrast Leakage Filter Code
- GLM_L1b_010n – Transfer Noise Filter Code
- GLM_L1b_010o – Coherency Filter Code
- GLM_L1b_010r – Radiation Filter Code
- GLM_L1b_010s – Second Level Threshold Filter Code
- GLM_L1b_010t – Crosstalk Filter Code

Monitoring & Analysis Method: Take the L0 output stream, run it through the operational code with the Solar Glint filter turned off, and perform the same run with the Solar Glint

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

filter turned on. Run the AWG spec Solar Glint filter algorithm and compare the output using VaLiD with the operational code output. Since the filter is designed to remove glint, but not remove lightning, datasets with and without glint should be chosen.
Tools Needed: VaLiD, Cluster/Filter, SITs, and other routine in-house lightning analysis tools.

A.2.9 GLM_INR_011 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM INR with comparisons to well-located ground points
Reference MRD: 1259
Start Time/Duration: The start and duration times depend (only in part) on lightning occurrence.
GOES-R Data Type(s): INR information (L0 and associated gridded images, GLM L2, and ABI visible channel images).
General Success Criteria: If the GLM geolocation is good to within ½ pixel (about 4 km), the GLM will have met success criteria.
Provisional Success Criteria: If the number of ground point locations tested and analyzed by the GLM PLPT group for each of these PLPTs in each region and time is at least 100, these PLPTs will contribute to the Provisional Validation level.
Dependencies: 100 locations/flashes geolocated (day & night)

- GLM_INR_011a – GLM Background (BG) data (L0) & associated gridded images, and ABI visible channel
- GLM_INR_011b – GLM L0, L2
- GLM_INR_011g – Daytime GLM BG data & associated gridded images with clear coastlines
- GLM_INR_011l – GLM L0, L2

Validation Data: The GLM uses INR information to locate background and lightning data to locations on the Earth. Compare those locations to those same locations as determined by well-located ground systems

- GLM_INR_011a – Comparison of GLM Background Images to ABI Derived Features
- GLM_INR_011b – Comparison of GLM Background Images and Laser Produced Artificial Lightning Locations to Laser Beacon Locations (if available)
- GLM_INR_011g – Comparison of GLM Background Images to Known Ground Landmarks and Coastlines
- GLM_INR_011l – Comparisons of Lightning Locations Derived from GLM INR to Lightning Locations Determined by Well Characterized Lightning Location Systems (e.g., GLM_L2_001, GLM_L2_002, GLM_L2_004, GLM_L2_005, and GLM_L2_006 series).

Monitoring & Analysis Method:

- GLM_INR_011a – Identify simultaneous daytime GLM BG and ABI bright targets (clouds) throughout the day. Compare offset between the ABI and GLM BG target throughout the day. During day and night, verify that GLM lightning occurs within regions of cold IR brightness temperatures as observed by ABI.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

- GLM_INR_011b – If available, operate the laser beacon at times when it is visible to the GLM. Collect the times of the laser beacon signals and compare them to the output of the GLM backgrounds and events. Compare offset between the known laser beacon locations and the GLM BG and event locations throughout the day. Some GLM L0-L1b filters may need to be turned off to allow the laser beacon data to pass through to the end of the L2 code.
- GLM_INR_011g – Compute GLM BG geolocation from spacecraft and instrument pointing parameters, and compare GLM BG coastline/surface feature location with those in the map database.
- GLM_INR_011l – Take flashes processed by PLPT sets 001-006 and use their locations to compare with the GLM determined locations.

Tools Needed: VaLiD, INR/Parallax, SITs, and other routine in-house lightning analysis tools.

A.2.10 GLM_RAD_012 series

Required for satellites: 16, 17, 18, 19

Objective: Validate GLM background deep convective cloud (DCC) radiances and radiance trending with comparisons to other measures of background radiances

Reference MRD: 1260

Start Time/Duration: The start and duration times depend on lightning occurrence.

GOES-R Data Type(s): GLM background radiances (GLM L0 and associated gridded images).

General Success Criteria: If the GLM DCC BG radiance calibrations agree with those previously or currently found by other calibrated systems.

Provisional Success Criteria: If the number of DCC pixel values tested and analyzed by the GLM PLPT group for each of these PLPTs in each region and time is at least 5000, these PLPTs will contribute to the Provisional Validation level.

Dependencies: To properly determine the DCC, solar angles and spacecraft viewing angles will be needed.

- GLM_RAD_012i – Daytime GLM BG data & associated gridded images, and coincident ISS-LIS data
- GLM_RAD_012t – Daytime GLM BG data & associated gridded images and archived ISS-TRMM data

Validation Data:

- GLM_RAD_012i – Comparison of Background DCC Values to ISS-LIS Background DCC Values
- GLM_RAD_012t – Comparison of Background DCC Values to Historical/Archived TRMM-LIS Background DCC Values

Monitoring & Analysis Method:

- GLM_RAD_012i – The GLM saves a BG every 2.5 minutes. DCC are identified as ABI 10.7 µm channel pixels that have brightness temperatures less than 205 K. GLM BG pixels that are co-located with these ABI pixels are then identified as GLM DCC BG pixels. The ISS-LIS observations of DCC simultaneously observed by GLM will then be compared to see if the values are similar.

- GLM_RAD_012t – The GLM saves a BG every 2.5 minutes. DCC are identified as ABI 10.7 µm channel pixels that have brightness temperatures less than 205 K. GLM BG pixels that are co-located with these ABI pixels are then identified as GLM DCC BG pixels. The historical TRMM-LIS observations of DCC will then be compared to the current GLM values to see if the calibrations are similar.

Tools Needed: VaLiD, TT/DCC, SITs, and other routine in-house lightning analysis tools.

A.2.11 GLM_RAD_013 series

Required for satellites: 16, 17, 18, 19
Objective: Validate GLM event energies and energy trending with comparisons to other measures of event energies.
Reference MRD: 1259, 1261, 1264
Start Time/Duration: The start and duration times depend on lightning occurrence.
GOES-R Data Type(s): GLM event energy distributions from GLM L2 event energies.
General Success Criteria: If the GLM event energy calibrations agree with those previously or currently found by other calibrated systems.
Provisional Success Criteria: If the number of event energies tested and analyzed by the GLM PLPT group for each of these PLPTs in each region and time is at least 5000, these PLPTs will contribute to the Provisional Validation level.
Dependencies:

- GLM_RAD_013a – Calibrated GLM Event Data and coincident FEGS data
- GLM_RAD_013i – Calibrated GLM Event Data and coincident ISS-LIS data
- GLM_RAD_013t – Calibrated GLM Event Data historical/archived TRMM-LIS Event Energies

Validation Data: Measurements of Lightning event energy densities from space have previously been obtained by TRMM-LIS and currently (projected to be available during GOES-18 PLPT) by ISS-LIS. These energy densities can be converted to energy values to compare with GLM.
Monitoring & Analysis Method:

- GLM_RAD_013a – This PLPT will be activated during the field programs associated with the PLPT period. Compare GLM event energy values with those obtained from FEGS
- GLM_RAD_013i – This PLPT will be activated during the times the ISS-LIS is within the FOV of GLM during the PLPT period. Compare GLM event energy values with those obtained from ISS-LIS
- GLM_RAD_013t – Compare GLM event energy values with those obtained from TRMM-LIS

Tools Needed: VaLiD, TT/Lightning, SITs, and other routine in-house lightning analysis tools.

A.3 PLPTs that support FULL Validation maturity

A.3.1 GLM_L2_001 series

Same as GLM_L2_001 series for Provisional, except for:

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Full Validation Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.2 GLM_L2_002 series

Same as GLM_L2_002 series for Provisional, except for:
Full Validation Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.3 GLM_L2_003 series

Same as GLM_L2_003 series for Provisional, except for:
Required for satellites: 16, 17, 18, 19
Full Validation Success Criteria: If the number of storms detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 200, these PLPTs will contribute to the Full Validation level.
Dependencies: 200 storms detected (day & night)

A.3.4 GLM_L2_004 series

Same as GLM_L2_004 series for Provisional, except for:
Full Validation Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.5 GLM_L2_005 series

Same as GLM_L2_005 series for Provisional, except for:
Full Validation Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.6 GLM_L2_006 series

Same as GLM_L2_006 series for Provisional, except for:
Full Validation Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.7 GLM_L2_009 series

Same as GLM_L2_009 series for Provisional, except for:

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Full Validation Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.8 GLM_L2_0010 series

Same as GLM_L2_010 series for Provisional, except for:
Full Validation Success Criteria: If the number of flashes detected by the GLM and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.9 GLM_INR_0011 series

Same as GLM_L2_011 series for Provisional, except for:
Full Validation Success Criteria: If the number of locations tested and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 1000, these PLPTs will contribute to the Full Validation level.
Dependencies: 1000 flashes detected (day & night)

A.3.10 GLM_RAD_0012 series

Same as GLM_L2_012 series for Provisional, except for:
Full Validation Success Criteria: If the number of DCC pixel values tested and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 10000, these PLPTs will contribute to the Full Validation level.
Dependencies: 10000 DCC pixel values detected (day)

A.3.11 GLM_RAD_0013 series

Same as GLM_L2_013 series for Provisional, except for:
Full Validation Success Criteria: If the number of event energies tested and analyzed by the GLM PLPT group for each of these PLPTs in each region and time (day/night) is at least 10000, these PLPTs will contribute to the Full Validation level.
Dependencies: 10000 events detected (day & night)

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

B. Appendix B: GOES-R Series and Validation Reference Data

Table 5. Listing of all data sources potentially employed for GLM PLPT. If the table says "MOU" (Memorandum of Understanding), then the storage location is in the "Data From" column. If it is "In-house", then the data are stored at MSFC.

ACTUAL DATA			Minimum Needs[1, 6]		Maximum Needs[2]		GLM L1b-L2 PLPT Reference[5]
Data Name	Data Available	Data From	Data Quantity (in GLM FOV)	Duration (per day)	Data Quantity	Data Duration	
ATDnet	MOU	UK Met Office	100/1000 flashes	5/10	No Set Maximum	Full Validation Period	001a, 011l
BrazilDAT	MOU	INPE	100/1000 flashes	5/10			001b, 011l
CLDN	In-house	ECCC	100/1000 flashes	5/10			001c, 011l
ENTLN	In-house	Earth Networks	100/1000 flashes	5/10			001e, 011l
GLD360	In-house	Vaisala	100/1000 flashes	5/10			001g, 011l
LINET (national)	In-house	Nowcast	100/1000 flashes	5/10			001l
NLDN	In-house	Vaisala	100/1000 flashes	5/10			001n, 011l
RinDAT	MOU	INPE	100/1000 flashes	5/10			001r, 011l
STARnet	MOU	Univ. Sao Paulo	100/1000 flashes	5/10			001s, 011l
NALMA[&#]	In-house	NASA Server[6]	100/1000 flashes	5/10	No Set Maximum	Full Validation Period	002a, 011l
TLMA	MOU	ECCC	100/1000 flashes	5/10			002c, 011l
DCLMA	In-house	NASA Server[6]	100/1000 flashes	5/10			002d, 011l
FCLMA	MOU	Colorado State Univ.	100/1000 flashes	5/10			002f, 011l
NGLMA	MOU	Georgia Tech.	100/1000 flashes	5/10			002g, 011l
HLMA	MOU	TAMU	100/1000 flashes	5/10			002h, 011l
KSCLMA[&]	MOU	NASA Server[6]	100/1000 flashes	5/10			002k, 011l
NMLMA[&]	MOU	New Mexico Tech.	100/1000 flashes	5/10			002n, 011l
OKLMA[&]	MOU	OU-CIMMS	100/1000 flashes	5/10			022o, 011l
WTLMA	MOU	Texas Tech.	100/1000 flashes	5/10			002t, 011l
WILMA	In-house	NASA Server[6]	100/1000 flashes	5/10			002w, 011l
INTF	MOU	New Mexico Tech	100/1000 flashes	5/10			002a,k,n,o
LINET (local)	In-house	Nowcast	100/1000 flashes	5/10			001l
ABI	In-house	NASA Server[6]	20/200 thunderstorms	5/10	No Set Maximum	Full Validation Period	003a, 011a
NEXRAD Radar	MOU	NOAA-NWS	20/200 thunderstorms	5/10			003n
MSG SEVERI	MOU	EUMETSAT	20/200 thunderstorms	5/10			003s
WWLLN	In-house	Univ. of Washington	20/200 thunderstorms	5/10			003w
AGS	In-house	UAH, MSFC	100/1000 flashes	5/10	No Set Maximum	Full Validation Period	004a, 011l, 013a
ISS-ASIM	TBD[10]	ASDC	100/1000 flashes	5/10	No Set Maximum	Full Validation Period	005a, 011l
ISS-LIS[8]	In-house	NASA Server[6]	100/1000 flashes	5/10			005i, 011l, 013i
MTG-LI[9]	MOU	EUMETSAT	100/1000 flashes	5/10			005m, 011l
TARANIS[4]	MOU	CNES	100/1000 flashes	5/10			005t, 011l
HAMMA	In-house	UAH	100/1000 flashes	5/10	No Set Maximum	Full Validation Period	006h, 011l
KSCFMA	MOU	NASA Server[6]	100/1000 flashes	5/10			006k, 011l
GLM L2 Events, Groups, Flashes	In-house	NASA Server[6]	10000/100000 events	5/10	No Set Maximum	Full Validation Period	009c

GLM L0 Events	In-house	NASA Server[6]	10000/100000 events	5/10	No Set Maximum	Full Validation Period	010 series
GLM L1b Events	In-house	NASA Server[6]	10000/100000 events	5/10			010 series
GLM Geolocated Backgrounds	In-house	NASA Server[6]	10000/100000 pixels	5/10	No Set Maximum	Full Validation Period	011a, 011b, 011g
Laser Beacon	In-house	NASA Server[6]	20/50	2/4			011b
Landmarks[7]	In-house	NASA Server[6]	20/50	5/10			011g
ISS-LIS Backgrounds[8]	In-house	NASA Server[6]	5000/10000 pixels	5/10	No Set Maximum	Full Validation Period	012i
TRMM-LIS Backgrounds[3]	In-house	NASA Server[6]	5000/10000 pixels	5/10			012t
TRMM-LIS[3]	In-house	NASA Server[6]	5000/10000 events	5/10	No Set Maximum	Full Validation Period	013t

[&] Note that these networks will each be augmented by a ground-based broadband VHF lightning interferometer network as described in Appendix B, section B.16. The interferometer networks have even higher detection efficiency than the LMA networks, but shorter range (~25 km).
[#] Note that the NALMA is augmented with a local 11-station VLF/LF system called LIghtning detection NETwork (LINET) that provides additional details of the discharges; this local network is distinct from the national level (longer baseline) LINET system mentioned above in section A.2.1.
[1] For Provisional/Full Validation levels.
[2] There is no such thing as too much data. Based on lightning availability in the GLM FOV, various PLPTs will be activated in an attempt to validate as much of the GLM FOV as possible within the shortest period of time possible.
[3] Instrument no longer in orbit, will use historical data for validation.
[4] Instrument planned for launch no earlier than mid-October 2020 so may be available for GOES-18 PLPT period. Will be used in Full Validation period if available. If not available even during Full Validation, then the data (and related PLPTs) will not be activated.
[5] Data sources can be used for more than one PLPT.
[6] Given the "target of opportunity" nature of lightning data sources, the Provisional/Full validated data amounts are more of a guideline than hard limits.
[7] Landmarks to be derived from various sources (e.g. coastlines, city lights).
[8] Instrument likely to be available for GOES-18 PLPT period pending a mission extension beyond 2020, but unlikely to be available for the GOES-19 PLPT period.
[9] MTG launch delayed until 2022.
[10] Data agreement is expected to be in place prior to the GOES-18 PLPT period.

B.1 GLM L0 Output
Storage Location: LZSS
Access Process: Internet, NASA server
Spatial Coverage: GLM FOV
Temporal Coverage: Continuous
Contingency: None
Special Considerations: None

B.2 GLM L1b Output
Storage Location: MSFC
Access Process: Internet, NASA server
Spatial Coverage: GLM FOV
Temporal Coverage: Continuous
Contingency: None
Special Considerations: Data must be eGRES'd from the Ground System

B.3 GLM L2 Data (Events, Event energies, Groups, Flashes)
Storage Location: MSFC

Access Process: Internet, NASA server
Spatial Coverage: GLM FOV
Temporal Coverage: Continuous
Contingency: None
Special Considerations: None

B.4 Well Characterized Medium to Long Range Networks with Medium to High Detection Efficiencies and Low False Alarm Rates

- ATDNet (Arrival Time Difference NETwork)
- BrazilDAT (Sistema Brasileiro de Detecção de Descargas Atmosféricas)
- CLDN (Canadian Lightning Detection Network)
- ENTLN (Earth Networks Total Lightning Network)
- GLD360 (Vaisala Global Lightning Dataset)
- LINET (LIghtning detection NETwork): national
- NLDN (National Lightning Detection Network)
- RINDAT (Rede Integrada Nacional de Detecção de Descargas Atmosféricas)
- STARNet (Sferics Timing And Ranging NETwork)

Storage Location(s):

- ATDNet: UK Met Office
- BrazilDAT: INPE
- CLDN: ECCC (Environment and Climate Change Canada)
- ENTLN: MSFC
- GLD360: MSFC
- LINET: MSFC
- NLDN : MSFC
- RINDAT: INPE
  STARNet: University of Sao Paulo

Access Process: Internet, see Storage Location for server
Spatial Coverage: Varies from national to near global
Temporal Coverage: Full PLPT period
Contingency: If the data are not available the PLPT will not be activated
Special Considerations: None

B.5 Well Characterized Short Range Networks with High Detection Efficiencies and Low False Alarm Rates

- NALMA (North Alabama Lightning Mapper Array)
- TLMA (Toronto Lightning Mapper Array)
- DCLMA (District of Columbia Lightning Mapper Array)
- FCLMA (Fort Collins Lightning Mapper Array)
- NGLMA (North Georgia Lightning Mapper Array)
- HLMA (Houston Lightning Mapper Array)
- KSCLMA (Kennedy Space Center Lightning Mapper Array)
- NMLMA (New Mexico Lightning Mapper Array)
- OKLMA (Oklahoma Lightning Mapper Array)

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

- WTLMA (West Texas Lightning Mapper Array)
- WILMA (Wallops Island Lightning Mapper Array)

Storage Location(s):

- NALMA: MSFC
- TLMA: ECCC
- DCLMA: MSFC
- FCLMA: Colorado State University
- NGLMA: Georgia Tech
- HLMA: Texas A&M University (TAMU)
- KSCLMA: NASA/KSC
- NMLMA: New Mexico Tech
- OKLMA: University of Oklahoma - Cooperative Institute for Mesoscale Meteorological Studies (OU-CIMMS)
- WTLMA: Texas Tech
- WILMA: MFSC

Access Process: Internet, see Storage Location for Server
Spatial Coverage: Region ~250 km around the central location
Temporal Coverage: Full PLPT period
Contingency: If the data are not available the PLPT will not be activated
Special Considerations: None

B.6 Well Characterized Very Long Range Systems with Low (to no) Flash Detection Efficiencies but Medium Storm Detection Efficiencies

- ABI (Advanced Baseline Imager)
- NEXRAD (NEXt-generation RADar)
- SEVERI (Spinning Enhanced Visible and Infrared Imager)
- WWLLN (World Wide Lightning Locating Network)

Storage Location(s):

- ABI: MSFC
- NEXRAD: NOAA - NWS
- SEVERI: European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
- WWLLN: MSFC

Access Process: Internet, see Storage Location for server
Spatial Coverage: Coverage near global except for NEXRAD which is limited to the US
Temporal Coverage: Full PLPT period
Contingency: If the data are not available the PLPT will not be activated
Special Considerations: None

B.7 Well Characterized Very Short Range Optical Systems with Very High Flash Detection Efficiencies and Low False Alarm Rates

- FEGS (Fly's Eye GLM Simulator)

Storage Location: MSFC, University of Alabama, Huntsville (UAH)
Access Process: Internet, MSFC and UAH servers

Spatial Coverage: Below flight path
Temporal Coverage: Limited to flight times
Contingency: If the data are not available the PLPT will not be activated.
Special Considerations: None

B.8 Well Characterized Orbital Based Optical Systems with High Flash Detection Efficiencies and Low False Alarm Rates

- ISS-ASIM (International Space Station - Atmosphere-Space Interactions Monitor)
- ISS-LIS (International Space Station - Lightning Imaging Sensor)
- MTG-LI (Meteosat Third Generation - Lightning Imager)
- TRMM-LIS (Tropical Rainfall Measuring Mission - Lightning Imaging Sensor) [no longer in orbit]
- TARANIS (Tool for the Analysis of RAdiations from lightNIngs and Sprites)

Storage Location(s):

- ISS-ASIM: ASIM Science Data Center (ASDC) at the Technical University of Denmark (DTU)
- ISS-LIS: NASA/MSFC-GHRC
- MTG-LI: EUMETSAT Satellite Application Facilities (SAF)
- TRMM-LIS: NASA/MSFC-GHRC
- TARANIS: Centre national d'études spatiales (CNES)

Access Process: Internet, see Data Storage for server
Spatial Coverage: Near global
Temporal Coverage: Continuous
Contingency: If the data are not available the PLPT will not be activated
Special Considerations: None

B.9 Well Characterized Ground Based Electric Field Networks with High Flash Detection Efficiencies and Low False Alarm Rates

- HAMMA (Huntsville Area Marx Meter Array)
- KSCFMA (Kennedy Space Center Field Mill Array)

Storage Location(s):

- HAMMA: UAH
- KSCFMA: NASA/KSC server

Access Process: Internet, see Storage Locations for server
Spatial Coverage: Huntsville area (HAMMA), KSC complex (KSCFMA)
Temporal Coverage: Continuous
Contingency: If the data are not available the PLPT will not be activated
Special Considerations: None

B.10 Outputs of Cluster/Filter algorithm using specified code (L1b-L2 Clustering Code)
Storage Location(s): NASA/MSFC-GHRC
Access Process: N/A
Spatial Coverage: N/A

Temporal Coverage: N/A
Contingency: N/A
Special Considerations: N/A

B.11 Outputs of L0-L1b Filter Algorithms using specified codes

- Solar Glint Filter Code
- Contrast Leakage Filter Code
- Transfer Noise Filter Code
- Coherency Filter Code
- Radiation Filter Code
- Second Level Threshold Filter Code
- Crosstalk Filter Code

Storage Location(s):

- All in house (NASA/MSFC-GHRC)

Access Process: N/A
Spatial Coverage: N/A
Temporal Coverage: N/A
Contingency: N/A
Special Considerations: N/A

B.12 GLM INR databases of well-located ground points

- ABI derived features
- Laser produced artificial lightning locations to laser beacon locations. There will be one site at the Goddard Space Flight Center Satellite Laser Ranging Facility (GSFC SLRF) located at 76.5W, 39.0N. Another site is Monument Peak, CA.
- Examine cloud-free coastlines with good contrast in the geolocated GLM background images and compare with the IDL map background.
- Lightning locations determined by well characterized lightning location systems.

Storage Location(s): The ABI data will come from ABI L1b data storage. "Well characterized lightning location systems" will each have their own storage location addressed elsewhere in the RIMP.
Access Process: Internet, NASA server
Spatial Coverage: GLM FOV
Temporal Coverage: Continuous
Contingency: None
Special Considerations: None

B.13 Measures of Background Radiances

- ISS-LIS Background DCC Values
- Historical/Archived TRMM-LIS Background DCC Values

Storage Location(s): MFSC
Access Process: Intranet

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Spatial Coverage: GLM FOV
Temporal Coverage: Continuous
Contingency: None
Special Considerations: None

B.14 Measures of Event Energy

- FEGS Event Energies
- ISS-LIS Event Energies
- Historical/Archived TRMM-LIS Event Energies

Storage Location(s): MFSC
Access Process: Intranet
Spatial Coverage: GLM FOV
Temporal Coverage: Continuous
Contingency: None
Special Considerations: None

B.15 Field Campaign Data

- Flash detection efficiency (day/night) at well-characterized total lightning super sites
- Flash detection efficiency (day/night) at other land and ocean locations
- Flash location and time stamp accuracy
- Image navigation and registration (INR) accuracy

Source:

- Fly's Eye GLM Simulator (FEGS) on ER-2 aircraft
- Airborne Visible-Infrared Imaging Spectrometer – Next Generation (AVIRIS-NG)
- Scanning High-Resolution Interferometer Sounder (S-HIS)
- Lightning Instrument Package (LIP)
- Cloud Physics LiDAR (CPL [add-on capability])
- Cloud Radar System (CRS [add-on capability])

Storage Location(s): Collaboration Portal of NASA Distributed Active Archive Center (DAAC) located at the Global Hydrology Resource Center of UAH (http://ghrc.nsstc.nasa.gov/)
Access Process: Intranet, Internet
Spatial Coverage: GLM FOV coincident with ER-2 aircraft loiter time
Temporal Coverage:

- 20-30 hours of flight time distributed over 2 weeks for campaign Phase 1
- 70-80 hours of flight time distributed over 4 weeks for campaign Phase 2

Frequency of transmission: N/A
Contingency: None
Special Considerations: Required sample size on order of 1000 flashes observed for validation

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

B.16 Broadband VHF Interferometers [these augment the Lightning Mapping Array (LMA) data provided in section B.5 and are also Well Characterized Short Range Networks with High Detection Efficiencies and Low False Alarm Rates] and one local Huntsville LINET system.

- New Mexico Tech Interferometer for KSC, FL (KSC-INTF)
- New Mexico Tech Interferometer for New Mexico Tech (NM-INTF)
- New Mexico Tech Interferometer for Oklahoma (OK-INTF)
- Japanese Interferometer for Huntsville, AL (HSV-INTF)
- 11 station local LINET system for Huntsville, AL

Storage Location(s):

- KSC-INTF: NASA/KSC
- NM-INTF: New Mexico Tech
- OK-INTF: OU-CIMMS
- HSV-INTF: NASA/MSFC
- HSV-LINET: NASA/MSFC

Access Process: Internet, see Storage Location for Server
Spatial Coverage: Region ~25 km around the central location
Temporal Coverage: Full PLPT period
Contingency: If the data are not available, then the PLPT will not be activated
Special Considerations: None

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

C. Appendix C: PLT Details

Approved final PLT list and details can be found in the individual PLT forms. The list is repeated here for convenience and is not necessarily the final approved list. The stars (*) in the Test IDs are place holders for the GOES-R Series satellite number (i.e., 16, 17, 18, or 19).

C.1 **Test ID:** G*-C-GLM-001
***Required for satellites:** 16, 17, 18, 19
Test Name: Validate GLM Timing Settings and Image Quality
Objective: This test addresses two categories of image quality criteria: those that are inherent to GLM and must be characterized and those that can be affected by adjusting the camera settings.

- Inherent Image Quality Criteria:
  - Focus
  - Crosstalk
  - Solar glint
- Image Quality Criteria Affected By Camera Settings:
  - Dark offsets
  - Estimated gain
  - Headroom
  - Overshoot behavior

Note that the main test is G*-C-GLM-001, and it includes a sub-test (G*-C-GLM-007) that is an on-orbit calibration test for adjusting the CCD timing to reduce gain.
Success Criteria: Acceptable gain and headroom when imaging cloud scenes of varying illumination.
Data Requirements: Collect 24 hours of GLM data in normal background mode

C.2 **Test ID:** G*-C-GLM-002
***Required for satellites:** 16, 17, 18, 19
Test Name: Set GLM RTEP thresholds
Objective: RTEP threshold tuning consists of measuring the actual threshold-to-noise ratio (TNR) associated with each of 56x32 thresholds and adjusting the threshold as necessary to achieve a target TNR. The target TNR should be in the in the range of 3.9 to 5.3.
Success Criteria:

- Number of events per second generated by GLM is within the telemetry bandwidth requirements with sufficient margin to accommodate expected worst case conditions (currently set at 40000 events per second).
- Number of events per second is approximately equal over all 56 sub-arrays and over all background lightning conditions.
- Thresholds are sufficiently low that GLM meets detection efficiency performance requirements.

Data Requirements: Collect 24 hours of GLM data in normal background mode

C.3 **Test ID:** G*-C-GLM-003
***Required for satellites:** 16, 17, 18, 19

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Test Name: Set GLM Second Level Thresholds
Objective: Analyze L0 and L1b data (L1b data produced using Ground Processing Demonstration System [GPDS]) to determine refined second level thresholds. Confirm values are correct after additional observation, requires access to L1b data to confirm new thresholds are correct and were implemented correctly.
Success Criteria: No single pixel continuously produces events labeled as lightning after ground processing algorithms have been run at any given light level
Data Requirements: Collect 24 hours of GLM data in normal background mode

C.4 **Test ID:** G*-C-GLM-004
***Required for satellites:** 16, 17, 18, 19
Test Name: Validate GLM GPA Parameters
Objective: This test updates parameters for the event filtering ground processing algorithms. The event filtering ground processing algorithms include: solar glint, crosstalk algorithm (if implemented), CCD frame transfer, radiation, coherency, and contrast leakage.
Success Criteria: GLM instrument is estimated to meet false alarm rate and detection efficiency requirements. Without access to "ground truth" it is not possible to fully verify that these requirements are met.
Prerequisites/Dependencies: None
Data Requirements: Collect 24 hours of GLM data in normal background mode

C.5 **Test ID:** G*-R-GLM-006
***Required for satellites:** 16, 17
Test Name: Verify Solar Intrusion Criteria
Objective:
- This test evaluates background images and events during eclipse and compares to the zones of reduced data quality (ZRDQ) requirements.
- This test uses images and event data acquired during eclipse to characterize the impact of solar intrusion on background image quality and event data quality.

Success Criteria: Any solar intrusion stray light artifacts are consistent with predicted stray light characteristics and zones of reduced data quality (ZRDQ) requirements
Data Requirements: Collect 24 hours of GLM data in normal background mode

C.6 **Test ID:** G*-C-GLM-007
***Required for satellites:** 16, 17, 18, 19
Test Name: On Orbit Calibration
Objective: Set final register values that control the GLM image quality, and compare on orbit image quality with data collected during ground calibration. Note that this test is a subtest of G*-C-GLM-001.
Success Criteria:
- Part 1: Final register values that control the GLM image quality successfully determined and uploaded to the spacecraft and related ground system parameter values are updated. The minimum Analog to Digital Converter (ADC) offset at the

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

minimum on orbit ADC temperature (after register values are updated) should be approximately 25 DN.

- Part 2: 48 hours of data is successfully collected with the same settings that were used on the ground in order for on-orbit image quality to be assessed with respect to the ground image quality.

Data Requirements: Collect 48 hours of GLM data in normal background mode prior to opening door (during outgassing period). Collect an additional 48 hours of GLM data in normal background mode after door has opened.

C.7 **Test ID:** G*-C-GLM-008
***Required for satellites:** 17, 18, 19
Test Name: Event Filtering Cross Satellite Comparison
Objective: Assess GLM L1b filtering results across multiple GOES-R Series satellites, and improve false alarm rate and detection efficiency if cross-satellite comparison reveals significantly better parameter settings than were achieved in standalone PLT GLM-004.
Success Criteria: Cross satellite comparison completed, and CDRL079 filter parameters delivered (if warranted by test outcome).
Data Requirements: Collect 100 simultaneous hours of event and background data from multiple satellites with overlapping GLM FOV.

C.8 **Test ID:** G*-E-GLMINR-001
***Required for satellites:** 16, 17, 18, 19
Test Name: GLM Coastline ID INR Characterization Assessment
Objective: Assess background images from GLM to determine appropriate parameters for coastline ID algorithm.
Success Criteria: Coastline ID performs within requirements
Data Requirements: Collect 7 days of background images with GLM instrument in normal background mode

C.9 **Test ID:** G*-E-GLMINR-002
***Required for satellites:** 16, 17, 18, 19
Test Name: GLM Event Navigation Coarse Characterization Assessment
Objective: This test provides a coarse assessment of the navigation algorithms, including a validation of the RTEP map, and a check that the various reference frame transformations within the navigation algorithms are performed correctly.
Success Criteria: Navigated lightning events are shown to be in region where lightning would occur – cloud formations in background image.
Data Requirements: Collect 24 hours of data with GLM in normal background mode (Normal mode or diagnostic mode, with events enabled and backgrounds every 2.5 minutes)

C.10 **Test ID:** G*-P-GLMINR-003
***Required for satellites:** 16, 17, 18, 19
Test Name: GLM Background INR Performance Assessment

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Objective: Using GLM background images provided by Product Generation (PG), determine the location error of control points in the scenes with reference control point images.
Success Criteria: Demonstrate accurate Navigation in family with performance expectations
Data Requirements: Background images for this assessment are generated by the PG and are resampled to a virtual uniformly spaced CCD grid and have navigation data appended.

C.11 **Test ID:** G*-R-GLMINR-004
***Required for satellites:** 16, 17
Test Name: GLM Alignment Assessment
Objective: Perform assessments of ground control points in background imagery or matching background imagery to coastlines (or use cloud-free reference imagery) to determine 3-axis navigation offsets.
Success Criteria: With updated roll, pitch and yaw mounting parameters, the GLM ground processing algorithm is able to accomplish nominal coastline matching.
Data Requirements: GLM background imagery

C.12 **Test ID:** G*-E-GLMINR-005
***Required for satellites:** 17, 18, 19
Test Name: GLM Navigation Cross Satellite Comparison
Objective: Assess GLM L1b navigation results across multiple GOES-R Series satellites, and improve navigation accuracy if cross-satellite comparison reveals significantly better parameter settings than were achieved in standalone PLT GLMINR-002.
Success Criteria: Cross satellite comparison completed, and CDRL079 navigation parameters delivered (if warranted by test outcome).
Data Requirements: Collect 100 simultaneous hours of event and background data from multiple satellites with overlapping GLM FOV.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

D. Appendix D: Tools

With the exception of the Specialized Impromptu Tools, the completion of all L2+ validation tools for PLT/PLPT were completed during GOES-16 PLT. The point of contact (POC) for each tool is the GLM CWG unless otherwise noted in the individual test.

D.1 **Tool #1:** VaLiD
Location: National Space Science & Technology Center (NSSTC), Huntsville, AL
Description: Validate Lightning Data (VaLiD) works by reading all available ground-based lightning data. It then grids those data, along with GLM data, compares them, and outputs a "stoplight chart" of the grid boxes to graphically depict success and potential problems with GLM. It reports detection efficiency of GLM vs. any selected ground-based network. It also reports statistics on GLM time and location accuracy compared with other systems. These reports are generated for several different time periods.
Developer: Monte Bateman of the Universities Space Research Association (USRA)
Development schedule & handover plan: No handover; VaLiD is an in-house tool.
Data Dependencies: Reads all validation datasets provided in the PLPTs, as well as GLM data
Testing accomplished or planned: 100% complete

D.2 **Tool #2:** Cluster/Filter (Matlab tools for PLPT series 9 and 10)
Location: NASA/MSFC
Description: Matlab code that duplicates the L0-L1b and L1b-L2 cluster/filter codes.
Developer: Doug Mach (USRA)
Development schedule & handover plan: No handover; tool is in-house.
Data Dependencies: GLM data (either L0 or L1b, depending on the PLPT series)
Testing accomplished or planned: 100% complete

D.3 **Tool #3:** HUDAT **(**IDL for PLPT GLM 006h)
Location: UAH, http://www.nsstc.uah.edu/ats/bitzer/hudat.html
Description: A graphical user interface to analyze Huntsville Alabama Marx Meter Array (HAMMA) data and/or other lightning data sets, including Lighting Imaging Sensor (LIS), Lightning Mapping Array (LMA), National Lighting Detection Network (NLDN), Global Lightning Detection 360 (GLD360), and Earth Network Total Lightning Network (ENTLN). HAMMA User Data Analysis Technology (HUDAT), written in the IDL programming language, will be used to examine various characteristics of lightning with special emphasis on lightning energetics.
Developer: Phillip Bitzer (UAH)
Development schedule & handover plan: None, tool is developed and in-house.
Data Dependencies: None
Testing accomplished or planned: This is a mature network with years of development, testing, and published results already completed.

D.4 **Tool #4:** STROKE (IDL for PLPT GLM 006k)
Location: NASA/MSFC

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Description: STorm Retrievals frOm KSC E-Fields (STROKE), written in the IDL programming language, is used only in very limited situations, if at all, to perform deep dives of certain anomalies. The extreme deep dives involve examining ground-based electric fields, lightning field changes, and the charges deposited by lightning all from thunderstorms in the limited Kennedy Space Center (KSC) Florida region.
Developer: William Koshak (NASA/MSFC)
Development schedule & handover plan: None; tool is in-house.
Data Dependencies: KSC Field Mill (FM) data
Testing accomplished or planned: 100% complete

D.5 **Tool #5:** INR/Parallax **(**IDL for PLPT GLM 011)
Location: NASA/MSFC
Description: Compares location of GLM events/groups/flashes with lightning locations from ground based instruments in various regions of the field of view. Also analyzes errors as a function of view angle to assess parallax. Develop in IDL.
Developer: Dennis Buechler (UAH)
Development schedule & handover plan: None; tool is in-house
Data Dependencies: Need other lightning detection locations from ground based lightning systems, GLM and ABI background images, and laser beacon data.
Testing accomplished or planned: 100% complete

D.6 **Tool #6:** TT/DCC (IDL for PLPT series 012)
Location: NASA/MSFC
Description: Trending Tool (TT) can ingest GLM L0 and ABI IR data. Identify Deep Convective Cloud (DCC) GLM background (BG) pixels. Compare radiances from GLM with historic LIS DCC radiances to establish that GLM values are within family with LIS and to set a baseline for trending of GLM DCC radiance values.
Developer: Dennis Buechler (UAH)
Development schedule & handover plan: None; tool is in-house.
Data Dependencies: GLM geolocated & calibrated background images, ABI L1b & L2 data, solar zenith angle, solar azimuth angle, GLM zenith view angle, GLM azimuth view angle, and GLM L2 event data.
Testing accomplished or planned: The tool has been applied and tested extensively on TRMM/LIS data and on Visible Infrared Scanner (VIRS). 100% complete.

D.7 **Tool #7:** TT/Lightning (IDL for PLPT series 013)
Location: NASA/MSFC
Description: Trending Tool (TT) reads in GLM events/groups/flashes and their associated energies. Used to determine whether GLM energies are in family with LIS and other data sources. Also used to establish a baseline for GLM event/group/flash energies and to compare GLM event/group/flash energies with ISS/LIS and FEGS.
Developer: William Koshak (NASA/MSFC)
Development schedule & handover plan: None; tool is in-house.
Data Dependencies: GLM events/group/flashes, ISS/LIS, FEGS
Testing accomplished or planned: 100% complete

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

D.8 **Tool #8:** Product Monitor (PM, aka Lightning Monitoring Tool)
Location: Will be run by contractor staff at the NSOF under the guidance of the PAL.
Description: The Product Monitor is a component of the Ground System designed to continuously monitor product quality and metrics for all GOES-R Series instruments. The GLM component of the PM is also referred to as the Lightning Monitoring Tool (LMT), which alerts users if anything (e.g., detection efficiency) looks problematic. If these anomalies in the data cannot be resolved by the NSOF staff and PAL, they will further consult with the vendor and/or the AWG/CWG groups in Huntsville, AL for further "deep dive" analyses.
Developer: LMT is part of the GOES-R Ground Segment Product Monitor.
Development schedule & handover plan: N/A
Data Dependencies: N/A
Testing accomplished or planned: N/A
POC: PAL

D.9 **Tool #9:** CompareLLS
Location: University of Arizona (UA)
Description: A CompareLLS (Compare Lightning Location System) tool, written in the Matlab programming language, will be used to perform shallow and deep dives of the GLM data using a wide range of ground-based datasets discussed in this RIMP. CompareLLS will provide detailed statistics of location and timing errors, and flash detection efficiencies, for adjustable spatial domains.
Developer: Ken Cummins (UA)
Development schedule & handover plan: No handover. Huntsville CWG has ability to run CompareLLS at the NSSTC.
Data Dependencies: Reads lightning data in PLPT series 001 & 002, WWLLN, TRMM/LIS, and GLM data.
Testing accomplished or planned: 100% complete

D.10 **Tool #10:** XLMA
Location: New Mexico Tech (NMT)
Description: An X Lightning Mapping Array (XLMA) tool, written in the IDL programming language, will be used to perform detailed analyses of Lightning Mapping Array (LMA) data. XLMA is the standard for plotting plan views, altitude vs. time, and vertical cross-sections of the retrieved LMA VHF radio sources both for individual flashes and for entire storm complexes. The spatio-temporal evolution of individual lightning channels is mapped out, thereby providing excellent validation of GLM flash location and timing errors, and detection efficiency.
Developer: Paul Krehbiel and Bill Rison (NMT)
Development schedule & handover plan: No handover. Huntsville CWG has ability to run XLMA at the NSSTC.
Data Dependencies: All LMA datasets listed in PLPT series 002.
Testing accomplished or planned: This is mature code that has been used/tested over many years by the Huntsville CWG and broader lightning research community.

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

D.11 Tool #11: lmatools
Location: Texas Tech University (TTU)
Description: lmatools, written in the Python programming language, are used to perform several functions related to LMA data, e.g.: sort VHF source data into flashes; calculate flash areas, volumes, and channel lengths using a convex hull-based method; produce gridded products (flash extent density, flash invitation density, average flash area, VHF source density) derived from flashes; calculate time series statistics of flash rate and size data using storm cell polygons; simulate LMA performance characteristics.
Developer: Eric Bruning (TTU)
Development schedule & handover plan: No handover. Huntsville CWG will have ability to run lmatools at the NSSTC.
Data Dependencies: All LMA datasets listed in PLPT series 002.
Testing accomplished or planned: Basic python notebook code has been built, tested, and demonstrated. Extensive add-ons are under continual development and are available on Github.

D.12 Tool #12: FEGST
Location: NASA/MSFC
Description: Fly's Eye GLM Simulator Tool (FEGST), written in IDL, is used to display and analyze FEGS data and help compare it with other lightning optical datasets (e.g., ISS/LIS). Some FEGS data are also ported to VaLiD for validation inter-comparisons.
Developer: Mason Quick and Rich Blakeslee (NASA/MSFC)
Development schedule & handover plan: None; in-house tool that was used during the GOES-16 Field Campaign.
Data Dependencies: FEGS, LIP
Testing accomplished or planned: The FEGS hardware and the FEGST software were both completed and tested in advance of the GOES-16 Field Campaign.

D.13 Tool #13: ADTs
Location: NSSTC, Huntsville, AL
Description: Ancillary Dataset Tools (ADTs) will be developed for processing datasets such as NEXRAD, SEVERI, ABI (especially cloud top height for parallax analyses), and WWLLN; some of these tools will be piggybacked onto VaLiD. The ADTs are simply used to make gross assessments/confirmations of where the basic storm activity resides (i.e., providing a quick look confirmation of where/when GLM should be seeing various regions of thunderstorm activity across its field-of-view).
Developer: Doug Mach (USRA), Dennis Buechler (UAH), Monte Bateman (USRA)
Development schedule & handover plan: These are simple Matlab & McIDAS scripts used in analyses associated with PLPT series 003; no development process required.
Data Dependencies: NEXRAD, SEVERI, ABI, WWLLN
Testing accomplished or planned: 100% complete

D.14 Tool #14: SITs
Location: NSSTC, Huntsville, AL

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

Description: Specialized Impromptu Tools (SITs), written "on-the-fly" in various possible programming languages (e.g., Matlab, IDL, C, Mathematica) will be used to handle any analyses that are needed, but that were unexpected.
Developer: Doug Mach (USRA), Dennis Buecher (UAH), Monte Bateman (USRA), William Koshak (NASA/MSFC)
Development schedule & handover plan: Development plan is N/A since by definition these are impromptu tools. No handover since in-house.
Data Dependencies: Potentially any dataset mentioned in the GLM PLPT series.
Testing accomplished or planned: N/A

D.15 Tool #15: LATA
Location: NASA/MSFC
Description: Location And Time Accuracy (LATA) tool produces a variety of plots/histograms that characterize the overall location/time accuracy of GLM flashes/groups/events.
Developer: Katrina Virts (NPP/MSFC)
Development schedule & handover plan: Development of this Matlab tool is complete.
Data Dependencies: GLM events/group/flashes (Level 2)
Testing accomplished or planned: 100% complete

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.

E. Appendix E: Acronyms

The below acronym list covers a select set of acronyms associated with GLM and general GOES-R procedures. To see a more comprehensive list of acronyms used within the GOES-R Program, see the GOES-R Series Acronyms webpage at https://www.goes-r.gov/resources/acronyms.html.

Acronym	Definition
ABI	Advanced Baseline Imager
ACMP	Algorithm Change Management Plan
ADTs	Ancillary Dataset Tools
ASDC	ASIM Science Data Center
ATDNet	Arrival Time Difference NETwork
BG	Background
BrazilDAT	Sistema Brasileiro de Detecção de Descargas Atmosféricas
Cal/Val	Calibration and Validation
CCD	Charge Coupled Device
CG	Cloud-to-Ground
CLDN	Canadian Lightning Detection Network
CompareLLS	Compare Lightning Location System
CONOPS	Concept of Operations
DCC	Deep Convective Cloud
DCLMA	District of Columbia Lightning Mapper Array
DE	Detection Efficiency
DMS	Data Management System
ECCC	Environment and Climate Change Canada
ENTLN	Earth Networks Total Lightning Network
ESA	European Space Agency
ESPDS	Environmental Satellite Processing and Distribution System
FAR	False Alarm Rate
FCLMA	Fort Collins Lightning Mapper Array
FEGS	Fly's Eye GLM Simulator
FEGST	FEGS Tool
FOV	Field Of View
GHRC	Global Hydrology Resource Center
GLD360	Global Lightning Dataset
GLM	Geostationary Lightning Mapper
GOES	Geostationary Operational Environmental Satellite
GOES-R	GOES-R Series
GORWG	GOES-R Operational Readiness Working Group

GRB	GOES Rebroadcast
GREs	Ground Readiness Exercises
GSFC SLRF	Goddard Satellite Ranging Facility
HAMMA	Huntsville Area Marx Meter Array
HLMA	Houston Lightning Mapper Array
HUDAT	HAMMA User Data Analysis Technology
IC	Intracloud
INR	Image Navigation and Registration
ISS-ASIM	International Space Station - Atmospheric-Space Interactions Monitor
ISS-LIS	International Space Station - Lightning Imaging Sensor
ITCZ	Intertropical Convergence Zone
ITSC	Information Technology & Systems Center
KSC	Kennedy Space Center
KSCFMA	Kennedy Space Center Field Mill Array
KSCLMA	Kennedy Space Center Lightning Mapper Array
L0	Level 0
L1b	Level 1b
L2	Level 2
LINET	Lightning detection NETwork
LM	Lockheed Martin
LMA	Lightning Mapping Array
LMT	Lightning Monitoring Tool
LZSS	Level Zero Storage System
MIT LL	Massachusetts Institute of Technology – Lincoln Laboratory
MOST	Mission Operations Support Team
MSFC	Marshall Space Flight Center
MTG-LI	Meteosat Third Generation - Lightning Imager
MVDTS	Mission Validation Test Data Set
NALMA	North Alabama Lightning Mapper Array
NCEI-CO	National Centers for Environmental Information in Colorado
NEXRAD	NEXt-generation RADar
NGLMA	North Georgia Lightning Mapper Array
NLDN	National Lightning Detection Network
NMLMA	New Mexico Lightning Mapper Array
NSOF	NOAA Satellite Operations Facility
NSSTC	National Space Science & Technology Center
OKLMA	Oklahoma Lightning Mapper Array
OPSCOM	Operational Concepts
OSPO	Office of Satellite and Product Operations
PAL	Product Area Lead

PDA	Product Distribution and Access
PLPTs	Post-Launch Product Tests
PLTs	Post-Launch Tests
PRO	Product Readiness and Operations
PSE	Program System Engineering
PS-PVR	Peer Stakeholder-Product Validation Review
RIMP	Readiness, Implementation, and Management Plan
RINDAT	Rede Integrada Nacional de Detecção de Descargas Atmosféricas
RTEP	Real Time Event Processor
SAF	Satellite Application Facilities
SDE	Storm Detection Efficiency
SEVERI	Spinning Enhanced Visible and Infrared Imager
SFAR	Storm False Alarm Rate
SITs	Specialized Impromptu Tools
Spec	Specification
STARNet	Sferics Timing And Ranging NETwork
STROKE	STorm Retrievals frOm KSC E-Fields
TARANIS	Tool for the Analysis of RAdiations from lightNIngs and Sprites
TLMA	Toronto Lightning Mapper Array
TNR	Threshold-to-Noise Ratio
TRMM-LIS	Tropical Rainfall Measuring Mission - Lightning Imaging Sensor
TT/DCC	Trending Tool for Deep Convective Clouds
TT/Lightning	Trending Tool for Lightning
UAH	University of Alabama in Huntsville
USRA	Universities Space Research Association
VaLiD	Validate Lightning Data
VE	Validation Event
WILMA	Wallops Island Lightning Mapper Array
WTLMA	West Texas Lightning Mapper Array
WWLLN	World Wide Lightning Locating Network
XLMA	X Lightning Mapping Array
ZRDQ	Zones of Reduced Data Quality

Check the GOES-R Portal at https://goesportal.ndc.nasa.gov to verify correct version prior to use.